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ON THE ORIGIN OF THE SUBTERRANEAN FAUNA OF NORTH AMERICA.

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Having, in my essay on the Cave Fauna of this continent, attempted to bring together as many facts as possible bearing on this subject, in now addressing the members of this Congress on the topic assigned me, it will be well to first give a *résumé* of the general subject and then to call attention to the additional facts and conclusions relating to this interesting topic.

In that work I took the view that the cave fauna of this country, and presumably of the world in general, was formed of emigrants or colonists from the surrounding regions of the upper world. I may be permitted to give an extract from what I published in 1888, in order to call attention to the scope of the inquiry.

"The conditions of existence in caverns, subterraneous streams and deep wells, are so marked and unlike those which environ the great majority of organisms, that their effects on the animals which have been able to adapt themselves to such conditions at once arrest the attention of the observer. To such facts as are afforded by cave-life, as well as parasitism, the philosophic biologist naturally first turns for the basis of

[1] Read at the meeting of the Zoological Congress of the World's Auxiliary Congress of the Columbian Exposition, Chicago, 1894.

his inductions and deductions as to the use and disuse of organs in inducing their atrophy. It is comparatively easy to trace the effects of absence of light on animals belonging to genera, families, or orders in which eyes are normally almost universally present. As we have seen in the list already given of non-cavernicolous animals, the eyes are wanting from causes of the same nature as have induced their absence in true cave animals. No animal or series of generations of animals, wholly or in part, loses the organs of vision unless there is a physical, appreciable cause for it. While we may never be able to satisfactorily explain the loss of eyes in certain deep-sea animals from our inability to personally penetrate to the abysses of the sea, we can explore caves at all times of day and night, of winter and summer; we can study the egg-laying habits of the animals, and their embryonic development; we can readily understand how the caves were colonized from the animals living in their vicinity; we can nicely estimate the nature of their food, and its source and amount, as compared with that accessible to out-of-door animals; we can estimate with some approach to exactitude the length of time which has elapsed since the caves were abandoned by the subterranean streams which formed them and became fitted for the abode of animal life. The caves in Southern Europe have been explored by more numerous observers than those of this country, and the European cave fauna is richer than the American, but the conditions of European cave-life and the effects of absence of light and the geological age of the cave fauna are a nearly exact parallel with those presented in the pages of my memoir. Moreover, the cave-life of New Zealand and the forms there living in subterranean passages and in wells, show that animal life in that region of the earth has been affected in the same manner. The facts seem to point to the origin of the cave forms from the species now constituting a portion of the present Plistocene fauna; hence they are of very recent origin."

The advances in our knowledge of cave-life made since 1886 and 1887, may be referred to under the following heads:

I. The fauna of caves, subterranean waters and wells, and their origin, investigated by H. Garman, Herrerao, Girard, Bolivar, Cope and Stejneger.

II. New facts regarding blind non-cavernicolous or lucifugous forms, comprising the anatomical and physiological investigations of Eigenmann, Hess, Kadyi, Schlampf, Ritter, and others.

III. Embryological observations on the conditions of the eyes in the young or in the embryos, tending to prove the origin of blind forms from normal eyed ancestors, by Teller and by Eigenmann.

IV. Theoretical discussions, by Weismann, Herbert Spencer, Lankester, and others.

I. It is very desirable to make a thorough survey of the animal life living at present in the region around the entrances of caves, in order to ascertain the eyed forms from which the blind ones may have originated. This Professor Garman has begun to do for the cave-region of Kentucky. In his article in "Science," on the origin of the cave-fauna of Kentucky," while he remarks that "the geological evidence is all that could be desired for proof of a recent origin of the caves themselves," he dissents "from the conclusions which have been drawn from this proof, as to the recent origin of the blind animals," claiming that animals which burrow in the soil everywhere show a tendency to loss of the organs of vision," and that "the originals of the cave species of Kentucky were probably already adjusted to a life in the earth before the caves were formed," and adds, "I cannot believe that there has been anything more than a gradual assembling in the caves of animals adapted to a life in such channels. In this view of the matter the transformation of eyed into eyeless species appears to have been much less sudden and recent than has been supposed." He illustrates his point by the "definite example of the blind crustacean, *Caecidotaea* (Asellus) *stygia,* which, though first discovered in caves, is also widely distributed in the upper Mississippi Valley, occurring as far east as Pennsylvania. "It is, throughout its range, a creature of underground streams, and is nowhere more common than on the prairies of Illinois

(the last place in the country in which one would expect to find a cave), where it may be collected literally by the hundreds at the mouths of the tile-drains and in springs. In Kentucky also it is not more abundant in the cave region than elsewhere, being very frequently common under rocks in springs and in streams flowing from them, even during its breeding season. It is only natural that such a crustacean should have found itself at home in Mammoth Cave when this cave was ready for its reception."

"I scarcely see what grounds there are for supposing that the present cave species are older than the remaining Quaternary fauna. All the blind and eyeless or partially eyed species must, in the beginning, have descended from normally-eyed forms, while the loss of vision or the disappearance of eyes, even where the rudiments of eyes remain, may, in some cases, have been comparatively sudden (by which we mean after several generations, or less, say, than a hundred), or in others have required hundreds of generations. In some cases, as in that of *Caecidotaea*, forms living in subterranean streams or under stones or buried in the soil, may have become already modified before being carried, or before migrating into the caves."

Mr. Garman then refers to the blind fishes, giving some new facts regarding their distribution. Finally he writes of the distribution of the blind beetles of the genus Anophthalmus, and gives an interesting account of a new species (*A. hornii*) discovered in fissures in the Trenton limestone of Lexington, Ky. This is an interesting example of the way in which a species living in conditions intermediate between an out-of-door life under stones or in the soil and in caves, becomes gradually adapted to a cavernicolous existence. The author also states his belief "that there appears to have been, after the Champlain period, a migration towards Mammoth Cave of cave insects from the south and east, when the continent had not been so greatly affected by changes of level as was the Mississippi Valley. Mr. Garman also sees nothing to indicate that cave animals have ever been more completely isolated than they are now, a view with which we agree. This does not conflict with the general

view we have expressed that isolation is an important factor in the evolution of the fauna of caves, of subterranean waters, and of other dark situations.

Other additions to our subterranean fauna have been noticed by Mr. S. Garman, who finds in the caves of southwestern Missouri, in which are subterranean streams, besides *Tiphlichthys subterraneus* Girard a new species of blind crayfish (*Cambarus setosus* Faxon); what "seems" to be *Ceuthophilus sloanii* Pack. and *Asellus hoppiae* Garman, "from Day's Cave, in mud under stones;" the latter form seems to be a genuine, eyed *Asellus*, and allied to an undetermined species represented on Pl. IV, fig. of our memoir, collected from a brook near Lancaster, Ky. The six other species of invertebrates mentioned belong to common out-of-door species, including a dragon-fly, a Dineutes, and a Hydrotrechus, and need not have been mentioned in connection with cave insects, as multitudes of insects naturally occur at or near the mouth of caves.

Here might be mentioned the interesting discovery by Mr. Nathan Banks of the common Phalangid of Wyandotte Cave, *Scotolemon flavescens* Cope, "under stones on the Virginia shore of the Potomac near Washington, D. C.," which, he says, "does not differ from cave specimens."[2]

A blind Salamander has also been discovered in this country by Mr. Stejneger. In the Rock House Cave, Missouri, on the walls, about 600 feet from the entrance, occurred a blind salamander (*Typhlotriton spelaeus*), forming a new genus and species of the family Desmognathidae. In the single adult captured the eyes are said to be "concealed under the continuous skin of the head." A larva was found, but, strangely enough, the condition of the eyes in the young is not referred to.

Passing out of our territory into Mexico, Professor Alfonso L. Herrera describes the results of his researches on the fauna of Cacahuamilpa Grotto, in Mexico. The new or more interesting forms are the following:

[2] The Phalangida Mecostethi of the United States. Trans. Amer. Ent. Soc., XX, 149-152. June, 1893.

Insects.

Choleva cacahuamilpensis (Ch. spelaea Bilmk.).
Tachys cacahuamilpensis (Bembidium unistriatum Bilmk.).
Ornix cacahuamilpensis (Ornix impressipenella Bilmk.).
Pholeomyia cacahuamilpensis Herrera.
Phalangopsis cacahuamilpensis Herrera (Ph. annulata Bilmk.).
Lepisma cacahuamilpensis Herrera (L. anophthalma Bilmk.).

Arachnida.

Phrynus cacahuamilpensis Herrera (Ph. mexicanus Bilmk.).
Drassus cacahuamilpensis Herrera (D. pallidipalpis Bilmk.).
Nesticus cacahuamilpensis Herrera (Pholcus cordatus Bilmk.).

Myriopoda.

Scutigera cacahuamilpensis Herrera.

Crustacea.

Armadillo cacahuamilpensis Bilmk.

I have received from Professor Herrera an eyeless Asellid crustacean taken from a well at Montery, Leon, Mexico. It shows no traces of eyes, and apparently belongs to a new genus, the species also being undescribed.

II. New Facts Regarding Blind, Non-cavernicolous, or Lucifugous Forms.

Although not a cave-dweller, the blind goby of the Californian coast lives in similar conditions and tells the same story as the blind Proteus of the cave of Adelsberg or the blind salamander of the Missouri Cave, of the loss of eyesight by disease. The blind goby (*Typhlogobius californiensis* Steindachner) occurs abundantly at Point Loma, San Diego, under rocks between tide-marks in holes made by "crabs" (more properly, shrimps). As Professor C. H. Eigenmann tells us, in his paper on the "Fishes of San Diego:" "It has been found nowhere else about San Diego, but has been taken at Ensenada. Its

habitat is, as far as known, quite limited. In its pink color and general appearance it much resembles the blind fishes inhabiting the caves of southern Indiana. Its peculiarities are doubtless due to its habits. The entire bay region is inhabited by a carideoid crustacean which burrows in the mud. It, like the blind fish, is pink in color. Its holes in the bay are frequented by Cleavelandia, etc., while at the base of Point Loma, where the waves sometimes dash with great force, the blind fish is its associate. . . . . In the bay the gobies habitually live out of the holes, into which they descend only when they are frightened, while at Point Loma this species never leaves its subterranean abode, and to this fact we must attribute its present condition.

"How long these fishes have lived after their present fashion it would be hard to conjecture. The period which would produce such decided structural changes can not be a brief one. The scales have entirely disappeared, the color has been reduced, the spinous dorsal has been greatly reduced; not only have the eyes become stunted, but the whole frontal region of the skull, and the optic nerves have been profoundly changed.

"The skin, and especially that of the head, has become highly sensitized. The skin of the snout is variously folded and puckered and well-supplied with nerves; the nares are situated at the end of a fleshy protuberance which projects well forward, just over the mouth. At the chin are various short tentacles, and a row of papillae, which very probably bear sensory hairs similar to those represented in Figs. 15 and 16 (Plate XXIII), extends along each ramus of the lower jaw, and along the margin of the lower limb of the preopercle. The eye is, however, the part most seriously affected. In the young, Fig. 7, it is quite evident, and is apparently functional. Objects thrust in front of them are always perceived, but the field of vision is quite limited. With age, the skin over the eye thickens, and the eyes are scarcely evident externally. As far as I could determine, they do not see at this time, and certainly detect their food chiefly, if not altogether, by the sense of touch. A hungry individual will swim over meats, fish or a mussel, etc., intended for its food without perceiving it by

sight or smell, but as soon as the food comes in contact with any portion of the skin, especially of the head region, the sluggish movements are instantly transformed, and a stroke of the fins brings the mouth immediately in position for operations."

Here, again, it may be observed that this blind fish is probably not older than the beginning of the Plistocene period, since we know that the coast of California has been rising since the Pliocene epoch, and therefore the coast lines have materially changed since the end of the Tertiary.

For a very full and elaborate account of the degenerate eyes of this blind fish we are indebted to Mr. W. E. Ritter, in an essay published during the present year. Besides the eyes he treats histologically of the integumentary sense papillae, and of the integument of this animal, giving a summary of his results on pp. 96 and 97, which we in part reproduce.

1. In the smallest examples of the blind goby studied, the eyes, though very small, are distinctly visible even in preserved specimens, the lens being plainly seen. In the largest specimens, on the other hand, they are so deeply buried in the tissue as to appear even in the living animals as mere black specks, while in preserved ones they are, in many cases, wholly invisible.

2. As is the case with rudimentary organs in general, the eye is subject to great individual variation in size, form, and degree of differentiation.

3. The only parts of the normal teleostean eye of which no traces have been found are the *argentea*, the *lamina suprachoroidea*, the *processus falciformis*, the cones of the retina, the vitreous body proper, the lens capsule, and, in one specimen, the lens itself.

4. In the parts present the rudimentary condition of the organ is seen in the very slight development of the choroid; in the fact that the choroid gland is composed entirely of pigment; in the fact that the iris, though of fully the normal thickness, is almost entirely composed of pigment; with great proportional thickness of the pigment layer of the retina and the entire absence in it of anything excepting pigment; in the minute size of the optic nerve, and finally in the small size of the *motores oculi*.

5. The surest evidences of actual degeneration are found, first, in the greatly increased quantity of pigment, and secondly, in the presence of pigment in regions where none is found in the normal eye, as in the hyaloid membrane.

6. On comparing the eyes of all blind vertebrates that have been most carefully studied, all may, in a general way, be said to be passing along the same degenerative path.

7. The eyes of blind vertebrates furnish very little evidence on the question whether structures in undergoing actual degeneration in ontogeny follow the reverse order of their phylogeny.

Ritter also states that from the works of European authors it is possible to make a detailed comparison of the eyes of Typhlogobius with those of *Proteus anguinus* and of the European mole, which he proceeds to do. On the whole, the eye of Proteus is more rudimentary than that of either Typhlogobius or Talpa, the lens being absent in the cave Amphibians. All authors, except Semper, are agreed that the optic nerve is present in both Proteus and Talpa, but Ritter finds no account of it ever having, in either of these animals, a pigment-sheath in its passage through the retina, such as occurs in Typhlogobius.

III. Embryological Observations on the Condition of the Eyes in the Embryo or in the Young, proving the Origin of the blind or eyeless Forms from normally-eyed Ancestors.

No complete observations have, so far as we are aware, been made on the embryology of cave animals, nor on that of eyeless non-cavernicolous forms, except in the few cases which we proceed to mention. In our essay on the Cave Fauna of North America (p. 139), we record the fact that in the young of the blind crayfish (*Orconectes pellucidus*), the eyes of the young are perceptibly larger in proportion to the rest of the body than in the adult, the young specimen observed being about half an inch in length. Previously to this, Dr. Tellkampf, in 1844, remarked that "the eyes are rudimentary in the adults, but are larger in the young." Mr. S. Garman

states, regarding the blind Cambarus of the Missouri Cave: "Very young specimens of *C. setosus* correspond better with the adults of *C. bartonii;* their eyes are more prominent in these stages, and appear to lack but the pigment." In the blind cave-shrimp (Troglocaris) of Austria, Dr. Joseph discovered that the embryo is provided in the egg with eyes.

In this connection should be recalled the observations of Semper in his Animal Life (p. 80, 81) on *Pinnotheres holothuriae,* which lives in the "water-lungs" of Holothurians, where, of course, there is an absence of light. The zoëa of this form has large, "well-developed eyes of the typical character. Even when they enter the animal, they still preserve these eyes; but as they grow they gradually become blind or half-blind, the brow grows forward over the eyes, and finally covers them so completely that, in the oldest individuals, not the slightest trace of them, or of the pigment, is to be seen through the thick skin, while, at the same time, the eyes seem to undergo a more or less extensive retrogressive metamorphosis."

In this connection may be mentioned the case of the burrowing blind shrimp (*Callianassa stimpsonii*) which has been found by Professor H. C. Bumpus, at Wood's Holl, Mass., living in holes at a depth of between one and two feet. He has kindly given me a specimen of the shrimp, which is blind, with reduced eyes, smaller in proportion to the body than those of the blind crayfish. He has also obtained the eggs, and has found that the embryos are provided with distinct, black, pigmented eyes, which can be seen through the egg-shell.

Recently, Zeller has studied the embryology of the Proteus of Adelsberg Cave, and has confirmed the statement of Michahelles, who, in 1831, discovered that the eyes of this animal are more distinct in the young and somewhat larger than in the adult. We quote and translate from Zeller's acccount:

"The development of the eyes is very remarkable; they are immediately perceived and present themselves as small, but entirely black and clearly drawn circular points with a slit which is very narrow and yet, at the same time, well-defined, and which penetrates from the lower circumference out to the middle.

"Indeed, one can hardly doubt that this astonishing development of the eye has been accomplished by the influence of light as has also the pigmentation of the skin, the reddish-white ground color of which appears thickly studded with very small brownish-gray points mixed with detached white ones, over the upper surface of the head and over the back down over the sides of the yellowish abdomen. Even on the edge of the fins (Flossensaum) the pigment is found. On the other hand there is a whitish spot over the snout as is likewise the case in the adult creatures which have been colored by the light. Both the under surface of the head and the entire abdomen are shown free from pigment like the limbs. . . . .

"I cannot specify very exactly as to when the pigmentation of the skin begins, but, in any case, it is very early and often earlier that the first beginning of the eyes can be discovered. The latter occurs toward the end of the twelfth week, at which time a thin, light gray line, which still appears overgrown, may be perceived, forming a half circle open underneath. Then while this line subsequently becomes clearer and darker and its ends grow further under and towards each other, there also takes place simultaneously a progression of the pigment larger towards the middle point, and the circle finally seems closed and filled up to the narrow slit mentioned above, which proceeds from the lower circumference and penetrates to the middle of the eye." (p. 570, 571.)

But the most striking discovery bearing on this subject is that of the condition of the eyes in the embryo and young compared with the adult of the blind goby of San Diego.

In his essay on the Fishes of San Diego, Professor Eigenmann briefly refers to and gives four figures (Pl. XXIV) of the embryo of Typhlogobius, Mr. C. L. Bragg having been fortunate enough to discover the egg in the summer of 1891. "The eyes develop normally, and those of Fig. 4 differ in no way from the eyes of other fish embryos." In this case, then, we have the simplest and clearest possible proof of the descent of this blind fish from individuals with eyes as perfect as those of its congeners.

We have been permitted by the Director of the United States National Museum to reproduce Professor Eigenmann's

excellent figures on the embryo, which tell the story of degeneration of the eye from simple disease of the organ, the species being exposed to conditions of life strikingly different from those of its family living in the same bay.

Before the discovery of the eggs, the youngest individual ever seen is represented in Pl. XXIII, fig. 7, its eyes being though small, yet distinct, and "apparently functional."

From these data it is obvious that future embryological study on cave animals will farther demonstrate their origin from ancestors with normal eyes.

IV. Theoretical Results bearing on the Theory of Descent, and more especially on the Neolamarckian Phase of the Theory, including the Doctrine of the Transmission of acquired Characters.

It is evident that the cases just cited afford the strongest possible proof of the theory of evolution in general, and do not militate against the truth of the Neolamarckian phase of the theory, which holds that by a change of environment, inducing disuse of the eyes, such variations, especially atrophy of a part or whole of the eyes and optic nerves and ganglia have become established, so as to result in the origin of new species and even new genera.

In the case of the blind goby, the burrowing Callianassa, the blind shrimp of Adelsberg Cave, and, in fact, nearly, if not quite all the blind forms now known, it is easy to see that the causes of variation are quite direct and appreciable, and that we do not need to invoke the principle of natural selection. And this is the view of Darwin himself.[3]

Besides the factors of change of environment and of disuse, the influence of the isolation of these forms from their out-of-doors' allies should not be overlooked. Take the case of the blind goby of San Diego Bay, or the Callianassa of Buzzard's Bay. Living in habitats remote from their congeners, obvi-

[3] In our work on the Cave Fauna of North America we have discussed the bearing of the facts of cave-life on the Darwinian and Lamarckian phases of evolution and have attempted to show that natural selection is inoperative in such cases as these, quoting Darwin's own words when referring to the loss of eyes in such animals: "I attribute their loss wholly to disuse" (p. 137–143).

ously as soon as their ancestors took up a burrowing mode of life, they were prevented from crossing with others of their species, and, probably, when in sporadic cases it did occur, very soon the swamping effects of intercrossing wholly ceased, only those in which the eyes had begun to degenerate interbreeding. After a few generations, therefore, owing to this isolation, the partially blind forms became fixed by heredity and by the very force of circumstances a blind or eyeless generation resulted.

These circumstances are paralled by the results of the intermarriage of deaf-mutes. Professor A. Graham Bell[4] has pointed out the danger of the establishment of a distinct variety of deaf-mutes with a special sign language of their own, since owing to their peculiar social environment and isolation in society there has lately arisen a strong tendency of deaf mutes to intermarry. The result, so far as gathered from a tolerably wide range of facts, shows that this incipient deaf mute strain or variety may have originated in two generations, since it seems probable, as Mr. Bell remarks, "that the oldest deaf mute in the country whose parents were both deaf mutes is now only a little past middle age."

Moreover, the cases we have cited tend to show that the origination of new species and genera of subterranean, as well as deep sea forms and others living in darkness, may have been induced after comparatively few generations. Future observations should be directed to this point. The moment that several individuals became isolated in dark holes or in caves, and more or less confined in such narrow limits, the effects of darkness would at once begin to be experienced, and some degree of adaptation to their changed conditions would immediately begin to operate. The individuals of this generation, i, e., the new comers in the cave, or those gobies which by burrowing in the mud had penetrated out of reach of their

[4] On the formation of a deaf variety of the human race. Memoirs National Academy of Sciences for 1883, Washington, ii, 179–262, 1884. The author points out the means of isolation of deaf mutes through asylums and national, state and city associations for promoting social intercourse, often resulting in intermarriages. He also gives "specimen cases to prove that in many different parts of the country deafness has been transmitted by heredity." (p. 210).

congeners, would doubtless become used to life in darkness. Their offspring of the first generation might or might not suffer some alteration in the visual organs, but doubtless some slight degree of physiological change would result; this might or might not be latent in the next generation, or it might crop out and become manifested in the first generation, or, if not in the first, in the second or third. As soon as the degeneration in the eye-sight began to become fixed by heredity, the process must have gone on rapidly, and, in a few generations, perhaps a dozen or twenty, or fifty, rather than many hundreds or thousands, or "numberless generations," as most writers since Darwin claim.

Now as deaf mutes already appear to breed true to their incipient strain or variety, whether congenitally deaf or rendered so by disease during the lifetime of either or both parents, it seems most probable that animals not at first congenitally blind, might have acquired, after having been carried into, and after living for some months or even years in darkness, the tendency to blindness, and have transmitted to their offspring such first steps in adaptation to their Cimmerian environment. It is difficult for any one, it seems to us, not hidebound by theory to imagine any other mode of procedure.

The steps in the process are these: 1, The change in environment from normal conditions to partial or total darkness; 2, At first a slight degree of adaptation to such change, if the animal survived at all; 3, Becoming gradually habituated to the darkness, compensation for the loss of eyesight would result in the stimulation of the senses of touch and smell; 4, Meanwhile the physiological change from loss of eyesight would react on the physical structure and the eye would begin to degenerate, and very rapidly, after a few generations, the optic nerves in some forms, or the optic lobes and nerves in others, would disappear, the vestiges of the outer structures of the eyes remaining in some forms long after the nervous connections between the eyes and the brain had become effaced; 5, Meanwhile, segregation would prevent intercrossing with new-comers provided with perfect eyes, and consequently would prevent the swamping of the new characters resulting from

disuse; 6, The new variety or species or genus, as the case might be, would become persistent, as long as the conditions of total or partial darkness continued.

Now these factors, so simple, so easily appreciated, that as early as 1802, Lamarck could see their force, though he only cited the case of the mole, for he knew nothing of cave animals—these factors would seem to be adequate for the production of these eyeless forms. These results of disuse seemed adequate to Darwin himself, the founder of the doctrine of natural selection; and yet the extreme Darwinians or Neo-darwinians of the present day push aside or are purblind to these fundamental factors of organic evolution, and insist that the *vera causa* of the evolution of these blind forms is either natural selection or panmixia, and they likewise deny that there is any ground for the operation of the principle of transmission of acquired characters.

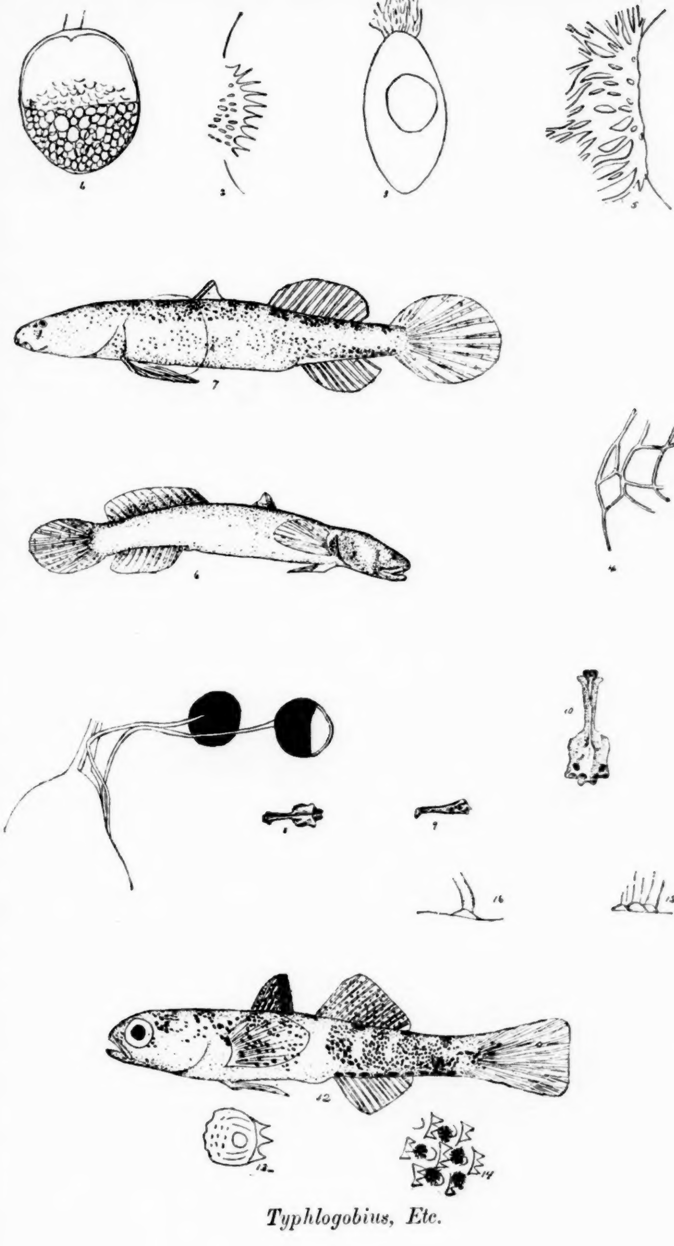
Weismann, who has rendered such eminent service to biology, in establishing the principle of heredity on a physical basis, as is well-known, pushes aside all these factors and explains the blindness of cave animals by a negative cause, "panmixia," i. e., the absence of natural selection. In his "Essays on Heredity" (1889) he claims that the small eyes of moles and of other subterranean mammals can be explained by natural selection, and remarks: "I think it is difficult to reconcile the facts of the case with the ordinary theory that the eyes of these animals have simply degenerated through disuse" (p. 86). He assumes that the degeneration of the eye of Proteus "is merely due to the cessation of the conserving influence of natural selection," and, he adds farther on, "this suspension of the preserving influence of natural selection may be termed Panmixia." And he even goes so far as to express the opinion that "that the greater number of those variations which are usually attributed to the direct influence of external conditions of life, are to be attributed to panmixia." He thus substitutes for the positive, tangible factors of change of environment, disuse and isolation, the negative and hypothetical one which he calls "panmixia."

In his discussion on this subject, as well as those of others who have adopted his views, Weismann, and his English translators, do not always give evidence of having carefully read the statements of those who have paid some practical attention to cave animals, Weismann only referring to the cases of the mole and of the Proteus. For instance, he remarks, "If disuse were able to bring about the complete atrophy of an organ, it follows that every trace of it would be effaced (pp. 90 and 292). Now in our "Cave Fauna of North America," published two years before the issue of the English translation of Weismann's essays, we have shown from microscopic sections that in the different species of blind beetles (Anopthalmus) not only is every trace of the optic ganglia and of optic nerves wanting, but also every trace of the eyes themselves. Also in the blind myriopods of Mammoth Cave, *Scoterpes copei,* no traces of the optic ganglia, optic nerves, or of any part of the eyes, including the pigment of the retina or the corneal lenses, were to be discovered. While in the blind crayfish the degenerate eyes are retained, in some individuals of an Asellid (*Caecidotaea stygia*), the eyes may be entirely effaced as well as the optic ganglia and optic nerves. On p. 118 of the memoir referred to there is a summary view of the effects upon the eyes, optic ganglia, and optic nerves, of different Arthropods resulting from living in total darkness.

Again, on p. 87, Weismann makes the following somewhat loose statement: "blind animals always possess very strongly developed organs of touch, hearing and smell." We have laid special emphasis in our essay on compensation by the development of tactile and other organs for the loss of eyesight or of eyes in cave animals, and while Weismann's assertion is true as regards the tactile and olfactory senses, it is curious that, from the direct and repeated observations of Dr. Sloan, which we quote, the blind fish occurring in Wyandotte Cave is, contrary to Wyman's and to Cope's suppositions, not sensitive to sounds.

The blind crayfish of Mammoth Cave, and also the species (*Orconectes hamulatus*) of Nickajack Cave, have, as we have ascertained by anatomical investigation, degenerate ears, so

PLATE XXIII.



Typhlogobius, Etc.

that the sense of hearing is, with little doubt, nearly, if not quite, obsolete (p. 128).

While, then, Weismann claims that there is a cessation of natural selection in the case of cave animals, another writer, Lankester, in a brief note in *Nature*, asserts that the blindness of cave animals is due to natural selection, remarking: "This instance can be fully explained by natural selection acting on congenital fortuitous variations. Many animals are thus born with distorted or defective eyes, whose parents have not had their eyes submitted to any peculiar conditions. Supposing a number of some species of Arthropod or fish to be swept into a cavern or to be carried from less or greater depths in the sea, those individuals with perfect eyes would follow the glimmer of light and eventually escape to the outer air or to the shallower depths, leaving behind those with imperfect eyes to breed in the dark place. A natural selection would thus be effected. In every succeeding generation (bred in the dark place) this would be the case, and even those with weak but still seeing eyes would, in the course of time, escape, until only a pure race of eyeless or blind animals would be left in the cavern or deep sea."

This explanation seems, however, vague and speculative, as well as inadequate, when we compare the kind of natural selection here invoked with such direct, powerful and readily appreciated factors as partial or total darkness (no plants being able to grow in caves, and only a very scanty fauna); added to the disease of organs whose very existence was originally due to the stimulus of light, and where, were it not for their enforced isolation, the swamping effects of crossing with eyed forms would constantly tend to prevent the permanent existence of blind or eyeless forms. Besides, how can the variations be fortuitous when the overshadowing and all-prevailing influence is darkness, this cause inducing a change primarily in a single organ, and, in a single sense, due to a single cause, urging the variation in a determinate way? Indeed, it may be questioned whether variations are ever "fortuitous" in the sense that they can arise independently of and are not controlled by the ever active forces of nature.

It is apparent that both of the last named writers, who have not themselves had a practical experience in collecting and studying cave animals and their surroundings, nor have carefully read the recent literature on the subject, are overmastered by speculative views, and prefer to make an extremely vague, unscientific and *a priori* speculation, rather than adopt an opinion based on the inductive method.

In refreshing contrast are the views of the veteran English philosopher, Mr. Herbert Spencer, who, like Darwin, fully appreciates the direct bearings of disuse as a fundamental factor, and, with his rare good sense and penetration, recognizes the probability of the active agency of the principle of the transmission of acquired characters in the origin of cave life.

Indeed, in caves, deep holes or burrows, or in dark subterranean streams and wells, to which the blind are restricted, we have conditions very closely parallel to those which obtain in asylums for the deaf and dumb. The array of facts presented by Professor A. Graham Bell and the danger which exists of the formation of a distinct deaf-mute variety of mankind, and the suggestions which he offers as to the most practicable way to arrest the further development of the incipient variety, all afford an interesting and striking parallel to the case of blind animals which are to be found living in caves and similar places.

The cave fauna, as a whole, is composed of individuals, all existing under the same conditions, living in partial or total darkness, and with eyes either defective or absent. Now, how did they come there? We occasionally find, all over the world, creatures with defective sight or imperfectly-developed eyes, but such cases are sporadic, and are not numerous enough in proportion to the normal population to breed together and to multiply. Where, however, individuals with more or less defective eyes should breed with normal mates, any tendency to the transmission of such defects would be wiped out by the swamping effects of crossing, owing to the immense preponderance of normal, vigorous forms with perfect vision. The whole tendency in nature in the upper world of light is to weed out such sporadic, defective forms. But in limestone

regions honeycombed with caves and permeated with subterranean streams, like those in the Mediterranean regions, France, Spain, and Austria, or in those of southern Indiana, Virginia, Kentucky and Missouri—in such regions as these, there exist the conditions favorable to the origination and perpetuity of blind forms. To give an example, eyed geodephagous beetles, such as the species of Trechus, of which there are so many in southern Europe, accustomed to burrowing in the soil under stones, when carried down by various accidents into dark crevices or into caves from which they are unable to extricate themselves, and too hardy and vigorous to succumb to the deadly effects of a life in perpetual darkness, and with, perhaps, already partially lucifugous habits, such forms under these changed conditions survive, breed and multiply, finding just enough food to enable them to make a bare livelihood, and with just enough vigor to propagate their kind. We can easily imagine that in time, and indeed no very long period, the newcomers would soon become adapted to their new surroundings, an environment abnormal both from the absence of light, and from the lack of predaceous forms to devour them; and they would live on, weak, half fed, half blind, forced to make their asylum in such forbidding quarters.

Where are there, in such circumstances as these, any of the conditions which would imply that any struggle for existence or processes of natural or sexual selection in these trogloditic societies are possible? On the contrary, it seems to us that in such unwonted conditions as these, darkness, lack of suitable food, and lack of destructive, carnivorous forms, other than the blind species themselves, we are brought face to face with the more powerful, primary, purely physical agents, which have produced changes chiefly operating in a single direction, i. e., to destroy the vision and to more or less completely abolish the eyes. Here we see exemplified in a typical way the direct action of the Lamarckian factors, viz.: Change of surroundings, coupled with disuse of parts useless in such altered conditions, and then the enforced isolation, especially marked in the cases of the Proteus and of the blind crayfish, etc., which never occur out of caves, however it may be with those species

living in dark wells or subterranean streams, which have a more or less direct connection with the upper world.

As regards the problem of the transmission of acquired characters, it would appear that the case with cave animals is paralled by that of deaf mutes collected together in asylums, and united by various social organizations. It has been shown in a striking way by Mr. Turner, as quoted by Bell, that "before the deaf and dumb were educated, comparatively few of them married." Bell concludes, from an examination of the records of deaf mute asylums in the United States, "that of the deaf mutes who marry at the present time, not less than 80 per cent marry deaf mutes, while of those who married during the early half of the present century the proportion who married deaf mutes was much smaller."

It was also clearly indicated that "a hereditary tendency towards deafness, as indicated by the possession of deaf relatives, is a most important element in determining the production of deaf offspring," and "it may even be a more important element than the mere fact of congenital deafness in one or both of the parents."

It appears, then, that it is the segregation of deaf mutes, in-including nearly half of the deaf mutes who became deaf from accidental causes, which has led to the apparent increase of this incipient strain or breed of human beings. And the statistics and conclusions given by Mr. Bell appear to almost demonstrate the fact of the transmission of characters acquired during the lifetime of the individual, and that it is difficult to draw the line between this phenomenon and the transmission of congenital characters; the latter being, at present, the more frequent and therefore normal law of heredity, though it was not so in the beginning. For, as Bell, after a careful study of statistics, remarks, "The numbers of the non-congenitally deaf are evidently subject to great and sudden fluctuations on account of the epidemical diseases which cause deafness, whereas, the growth of the congenitally-deaf population seems to be much more regular."

Premising that heredity does not, at the best, always unerringly act, that its results are sometimes uncertain, even where

those with congenital variations breed together or intermarry, it is also to be taken for granted that it may, at times, be impossible to draw the line between the transmission of congenital and of acquired characters.

When a number, few or many, of normal, seeing animals enter a totally dark cave or stream, some may become blind sooner than others; in others there may be developed only a tendency to blindness, the eye itself being imperceptibly modified by disuse, while a certain percentage may possess the tendency plus a slight physical defect, either functional or organic, in the eyes, especially in the optic nerves and ganglia. The result of the union of such individuals and of adaptation to their stygian life would be broods of young, some with vision unimpaired, others with a tendency to blindness, while in others there would be noticed the first steps in degeneration of nervous power and of nervous tissue. Even in a succeeding brood, or in a third brood, we might have a few individuals which were born blind or partly so, and were compelled to feel their way about the cave, while the far more numerous members of the colony would only exhibit a tendency to the disuse of their eyes, attempting to see their way rather than to feel it. Thus, after a few, or only several generations, the society of troglodytes, vertebrate and invertebrate, might be compared to a newly-established asylum of deaf mutes or to an asylum for the blind, if they interbred in the same proportions.

At first, then, the number of cases of those not congenitally blind, but which, after living for most of their life time in darkness and becoming so modified that they could dispense with the use of their eyes, *pari passu* becoming more and more dependent on the exercise of their tactile organs—at first, such individuals as these would greatly preponderate.

So all the while the process of adaptation going on, the antennae and other tactile organs increasing in length and in the delicacy of structure of their olfactory and tactile structures, while the eyes were meanwhile diminishing in strength of vision and their nervous force giving out; after a few generations, (perhaps, judging by what we know of the sudden production of deaf mutes in human societies, only two or

three,) the number of congenitally blind would increase, and, eventually, they would, in their turn, preponderate in numbers.

It is also possible that the longevity of cave animals, owing to the absence of ordinary enemies and of casualties, such as occur in the upper world, even though the supply of food were greatly restricted, would be much greater than in epigaean regions. If this be so, then there is a more favorable opportunity for the development and fixation of the myopic condition in subterranean situations.

It thus appears that while the heredity of acquired characters was, in the beginning, the general rule, as soon as the congenitally blind preponderated, the heredity of congenital characters became the normal state of things, the inhabitants being all blind, and for generations breeding true to their specific and generic characters.

On the other hand if the conditions should be changed, and the cave become opened to the light, then we should expect a gradual reversion to their eyed ancestors. This process would, of course, be due to causes exactly opposite to those producing the blind form, i. e., the presence of light, etc. In such a case, neither natural selection nor panmixia would be the factors, although some one might give a high-sounding, "scientific" name to the supposed process. And this shows how inoperative can be natural selection or panmixia as true working causes of the transformation of species, compared with the operation of the fundamental factors of organic evolution postulated by the Neolamarckian.

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[5] This list is supplementary to that published in my essay on the Cave Fauna of North America Memoirs of the National Academy of Sciences, 1889, and includes some titles omitted in that bibliography, many of which are copied from Ritter's work.

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THE NUMERICAL INTENSITY OF FAUNAS.[1]

By L. P. Gratacap.

In the various aspects of the Development of Life upon the earth the attention of the student has been principally directed to the question of form, as a problem of derivation. The external configuration of the enclosing frame-work or envelopes of organisms, or the modified outlines of internal skeletons have been closely compared, and species have been defined upon their differences, and the record of the march of specific change, group segregation and class development compiled from their study. The enumeration of species as they multiply, or decrease and disappear has been made, and the successive expansions and contractions of the lineal avenues of descent extensively elaborated. The student has less frequently been brought to consider the question of number, the numerical increase of forms, or to attach any biological significance to the arithmetical rise or decrease of species. It is, upon a little reflection evident that the subject of numbers, if it admits of any determination, may have or must have, a direct connexion with the ease and spontaneity with which a new or old species maintains itself, and may prove an index of the severity of competition or of the difficulty of living in its field of zoological activity.

Assuming the rate of increase uniform, the apparatus and impulse to procreation identical in a number of species, that one, of course, will survive in the greatest numbers whose life is attended with the least friction, against whose functions and habits the smaller array of obstacles active and passive exist. The comparison of species in this respect, so far as it is used to make out the comparative adaptation of species to certain conditions, assumes of necessity an identical fecundity in each species, and the comparison has, therefore, valid probability between species of the same families, or genera or perhaps classes.

[1]Paper presented at Brooklyn Meeting of the Amer. Ass. Ad. Sci, Aug., 1894.

On the other hand a more recondite suggestion is made in this inquiry. Favorable conditions for the multiplication of a species, such as temperature, food-supply, freedom from enemies, habitability of station, etc., naturally assist numerical increase. But the speculation suggests differences in the time required for a species to attain *momentum*, the time required for it to reach the maximum rate of increase, when its vitality has attained such force as to most effectually overcome hampering conditions, and is recorded in the number of individuals produced at one period. This question touches the surmises made as to the manner of specific introductions. Does a species make its appearance in one example—as an individual—on the world's stage or, if diœcious, in pairs, and then proceed to establish its currency, and so in geometrical ratio of increase engage itself in subjugating its environment and dispersing or suppressing its competitors? Or do species appear in numbers, and from separated points of occupation begin spreading, until their divided areas coalesce, and their geographical coincides with their numerical maximum? Or finally does the manner of their entrance into life vary for different species, or the species of different groups in both these ways? It seems probable that the higher orders of animals—especially the vertebrates—are *sporadic* in their appearance, viz., differentiate as individuals, while the lower are *massive*, viz., differentiate in hosts.

Conditions being equal the invertebrates should reach their numerical maxima quicker than the higher vertebrates, and their maxima should, comparatively, reach enormously higher figures. What the functional activity of procreation in a new species is, cannot be determined. It would seem probable that if specific variation were a process of insensible or slightly sensible changes in forms or external physical features, the correlated disturbances of function would be imperceptible and the new species would carry on the work of self-propagation with the same energy as the allied species amongst whom it makes its appearance. The actual numerical results would be at first low, because of the smaller number of individuals of the new species and would increase as that number enlarged,

and the opportunities or occasions of procreation multiplied. Again it is necessary to consider a reversal of this. The sterility of the offspring of crossed parents of different species points to the fact that there are or may be functional changes in the powers of generation, and that the new species, is, by this law, made dependent for its successful extension, upon the intercourse of similar individuals. It is likely that in connection with the rise of a new species those organs concerned in reproduction have become modified, and the system of seminal secretion, which carries with it the power of perpetuating the new forms, has itself been more or less profoundly affected. From such considerations it seems fairly probable that new species appear in limited numbers, and acquire after time the full power of propagation until with increasing numbers the maximum of their numerical rise is reached, and then that decadence begins which ends in their disappearance. It will be understood that by "limited numbers" we mean such representations of species as are much below their later and more normal development.

It then appears from such considerations, without further detail, that the factors of numerical increase are two, the external or physical conditions of life, and the internal or biogenetic force of propagation. As regards the first, the external or physical conditions of life, it may be assumed that the appearance of a species must take place under favorable conditions, if we are to accept the Darwinian hypothesis, that specific origination means that very thing, the better adaptation of new species to reigning conditions than any other, for it is its preponderant aptitude for life under these conditions that brings the new species into existence. So that as regards the encouragement to increase given by the external conditions it is unexceptional or adequate, and the rate of multiplication is then made dependent upon the physiological factor, the power and provision for propagation. These favorable conditions will be temporary. They will be succeeded by others less favorable, and the species, started under way under the best external auspices will begin to work against physical detriments and brakes that will lower its vital momentum, and, unless

the biogenetic factor keeps up or even becomes intensified, the species begins its downward course, since numerical diminution means final extinction. The biogenetic factor, the influence of propagation, will, in all probability, decline with any changes in external conditions which affect the physical well-being of the organism, so that the sum of influences springing from external circumstances and internal conditions work conjointly to exhilerate or depress the life of the animal. Furthermore, although a new species responds more fittingly to its environment and possesses peculiar advantages over its companions, this species, it may be assumed, survives because it is less at odds with its surroundings, not because it is most appropriately placed. As it becomes more and more part of the new status which brought it into existence, its organism more and more nearly attains its limital fecundity.

The list of possible combinations of conditions upon the emergence of a species would then be four.

First.—Favorable Environment and High Vitality=procreative activity.

Second.—Unfavorable Environment and High Vitality.

Third.—Favorable Environment and Low Vitality.

Fourth.—Unfavorable Environment and Low Vitality.

The discussion of these four *as limital expressions*, covers the varying phases under which a species attains its numerical maximum. And this discussion assumes, for the sake of reaching definite results, that the species is considered as restrained by the boundaries of a limited area, an assumption not very much at variance with facts.

Favorable Environment and High Vitality.—In this case the species would rapidly rise to its numerical maximum, and maintain it as long as the environment and its own vitality remained propitious. But this very intensity of development would lead to the deterioration of the species, and bring about its own extinction. The competition between its own representatives would become exasperated through their great number, and this would drain the food-supply, while the excessive productivity would reduce procreative power. The zoological consequence, in this instance, would be quick

numerical expansion followed by a more or less abrupt decline. Darwin says (Origin of Species Chap. X, 1860). "There is reason to believe that the complete extinction of the species of a group is generally a slower process than their production; if the appearance and disappearance of a group of species be represented as before by a vertical line of varying thickness, the line is found to taper more gradually at its upper end, which marks the progress of extermination, than at its lower end, which marks the first appearance and increase in numbers of the species." In the case of favorable environment and high vitality the line would probably begin suddenly with a thickened end, continued and increased for some distance, and slope steeply to its termination. Two examples in paleontological history illustrate this; the Trilobitic fauna of the Upper Cambrian, the Potsdam of Wisconsin and Minnesota, and the successive Ammonitic faunas of the Jura-Lias in Europe.

Prof. Hall recognized and tentatively separated three horizons of the trilobitic beds of Wisconsin and Minnesota; the earlier trilobites were referable in numbers to the genus *Conocephalites* while *Dicelocephalus* emerges in the middle beds and becomes numerically important through these and the higher beds. Prof. Hall was struck with their extreme abundance, and records his own impressions in these words; "the multitude of individuals of a few species is really wonderful; for in some beds the layers may be separated at every inch, or even half inch, and yet the entire surface is covered with the dismembered parts of these ancient trilobites." As to the Ammonites of the Jurassic they are celebrated for the sharpness of lines of demarkation between beds abounding in great numbers of the different species.

Unfavorable Environment and High Vitality.—In this case there would result a variable numerical abundance according to the equilibrium established between these discordant factors, but the average result would be a numerical uniformity extended over a considerable length of time. The procreative power would replenish the losses by death, and keep up, at least at first, a uniform amplitude of life. The unfavorable environment would work a defeating influence upon procrea-

tion, and after a length of time, bring about a low vitality which in conjunction with the uncongenial surroundings would wind up the species.

Of course the term *unfavorable* is here used comparatively, not meaning *inimical*, because a new species upon the doctrine of adaptation could not arise in hostile circumstances, but meaning less favorable than the *most* auspicious surroundings. The result as measured in numerical estimates would be a low mean, which perhaps as the environment improved might increase. It is only likely that such conditions are present when a species migrates, or is invaded by a change of physical conditions less advantageous than those it has previously enjoyed. A new species with high vitality is hardly consistent with unfavorable environment at the beginning, and the category we are considering would only be exemplified in the numerical exhibit of species whose habitat has been affected unfavorably. The repression of great numbers of individuals at any one time would tend to lengthen the life of the species, inasmuch as it would relieve it from struggle in its own midst, and this would have a tendency to extend its days.

In the paleontological record the case of *Atrypa reticularis* seems to illustrate this numerical constancy. From the Upper Silurian in the Niagara through the Lower Helderberg, Oriskany Schoharie and Upper Helderberg it keeps up a more or less uniform though not excessive representation until diverging in the Devonian into *A. vexata* and *A. spinosa* it becomes itself more numerous seeming then to pass under the conditions of the first category—high vitality and favorable environment—and declining rapidly terminates in the Upper Hamilton. *Atrypa reticularis*, as is well known, does not attain a large size in the Silurian, but, according to Hall, exhibits considerable variety of form. It is in the stage of "*oscillation*," not yet having attained specific fixity and this fact of formal instability points to a lack of congruity between itself and its environment and leads us to consider it an example under this heading.

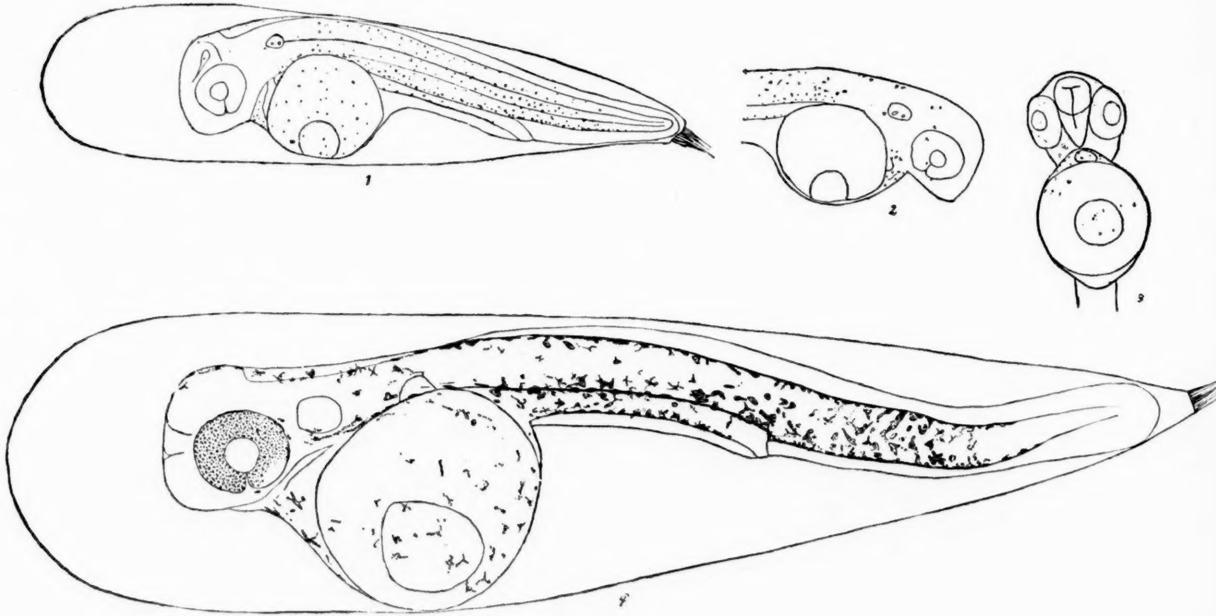
Favorable Environment and Low Vitality.—By "Low Vitality" we here designate a certain sluggishness in fecundity in cer-

tain animals though the value of the procreative energy considered at the instant of its exercise may be high. Evidently for such animals their duration in time will be conditioned largely upon favorable circumstances of life and without these they must undergo extinction. The numerical representation must always be small; it is essentially limited by their intrinsic predisposition to be slow breeders. This assumption seems applicable to species which without any apparent change in their environment become subject to a progressive failure in numbers. The history of invertebrate life on the earth's surface emphasizes this. Throughout similar conditions or what, from lithological evidence, seem *identical* conditions, species dwindle and disappear. On what hypothesis can this gradual vanishment be explained, except that the living momentum has run down, a physiological deterioration has set in, which must, no matter how auspicious be the physical requirements, compass the discomfiture and suppression of the species. Low vitality might also reasonably imply a certain functional weakness which affects the organic intregrity of a species. Under either implication, that of low procreative power or functional weakness, favorable environment fictitiously prolongs the life of the species and gives a deceptive appearance of stability to a species internally disintegrating. Its numerical ratio must be a reduced one.

Unfavorable Environment and Low Vitality.—This category symbolizes the rapid decline of a species, and is symptomatic of the final stages in its life-history. Where unfavorable conditions combine with intrinsic decrepitude the doom of a species is quickly sealed, and it vanishes from the scene scarcely noticed amidst the on-coming armies of new and intense competitors.

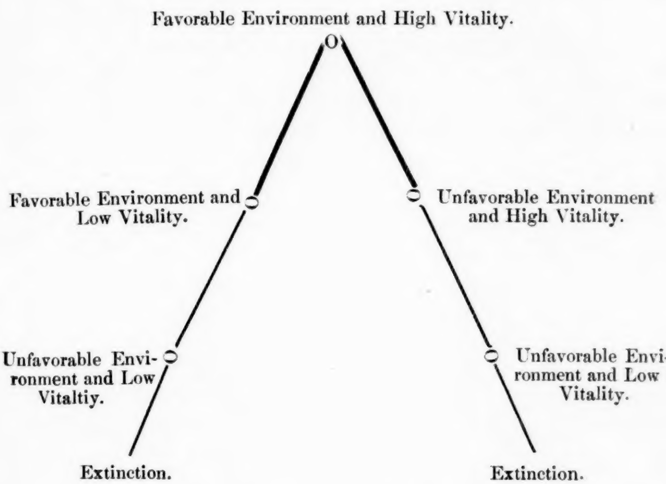
These four categories which we have epitomized, embodying the relations of *vitality* to *environment* and applied to the phenomena of the numerical abundance of a species, may be generally regarded as the formal stages of a species' decline. And we observe that the succession of these stages may follow one of two directions as divergent lines from an original condition. That original condition is *Favorable Environment and*

PLATE XXIV.



Typhlogobius.

High Vitality, for while these terms may not be co-existent upon the first appearance of a species they must quickly become so. A species originates, if we are to accept the Darwinian hypothesis by reason of its preponderant adaptation to new conditions, and if at first that adaptation is tentative or accidental, it soon becomes assured and necessary, upon the *settling down* of species and environment into a complete reciprocity. We then may expect two similar but contrasted stages to succeed this original, initial state, as is seen in the subjoined diagram; these stages presenting equivalent *numerical* zones, to be followed by two similar and identical stages, which in turn precede the extinction of the species.



The conjecture here delineated shows a species beginning under the favoring conjunction of vitality and adapted environment, rising in *numerical intensity* until a weakening of these elements sets in, and the species begins to decline in numbers. It may decline along a line of lessening vitality with environment constant, or, it may decline along a line of increasingly hostile surroundings with vitality constant, and it may be assumed that a stage of equipoise may be reached along either

of these lines wherein, however, the factors of environment and vitality are oppositely related. There would then be two stages of equal numerical efficiency, opposite in conditions but equivalent in effects, favorable environment and low vitality, and unfavorable environment and high vitality, and succeeding these as an inevitable sequence comes at the end of either road of retreat, the final stage of unfavorable environment and low vitality and the extinction of the species. Along either of the avenues of deterioration the numerical intensity is supposed to decline similarly but this superficial resemblance covers a radical contrast of agencies and we are brought to consider two kinds of strain; the strain of internal weakness, and the strain of external disparity. This introduces a crucial question we think in reference to the Darwinian hypothesis. That hypothesis assumes that species are perpetuated by the concordance declared between them and their surroundings, and it seems enclosed in this wide opening statement, that the Darwinian must allow a certain power of *provocation* upon organisms from exterior conditions, viz., that the inherent variability (fully emphasized by Darwin) of organisms is stimulated by changing environment while it should be more quiescent under unchanged circumstances of life. Without at present pressing this question the inference, we think, is reasonable. Therefore, in establishing a line of numerical decline for a species we have in this suggestion a form of test as to whether that decline arises from changing environment or changing vitality. If it proceeds from changing environment it will be, upon the Darwinian theory, accompanied by specific offshoots, and the disappearing species will sink from sight amidst the emergence of related species; but, if it proceeds from devitalization it will display a species dying as it were alone, unattended by the growth of related varieties, and passing away without those bequests of derivative forms which, in the other instance, represent the yet internally vigorous species struggling to maintain its empire under the guise of modified offspring. These propositions will, it may perhaps be conceded, repay more careful and detailed application to zoological history, as it has been written in the successive ages of geology.

THE DEVELOPMENT OF THE WING OF STERNA WILSONII.

By Virgil L. Leighton.

Although various students have investigated the structure and the development of the wing of the bird, many points still remain unsettled, and prominent among them, the relations of the carpal elements, the number of digits present and the comparison of these digits with those of the normal pentadactyl manus. Professor J. S. Kingsley suggested to me to attempt the solution of some of these problems and the studies detailed below were carried out in the Biological Laboratory of Tufts College under his direction. To him I owe the material—embryos of various stages of Wilson's tern, *Sterna wilsonii* from the Island of Penekese, Mass.—which formed the basis of my work.

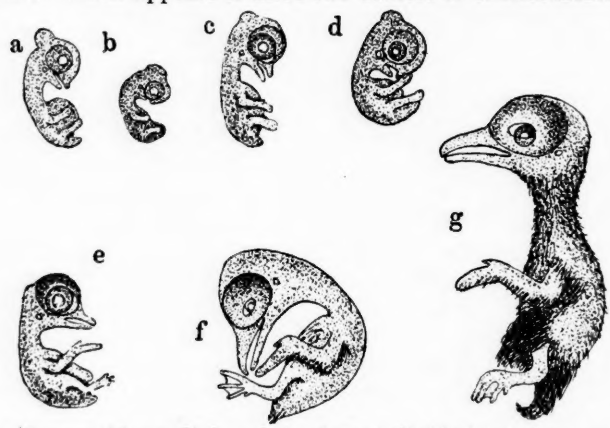
The alcoholic material was studied both in toto by clearing with oil of clove, and by means of serial sections. The latter proved far preferable and much more dependence can be placed upon results obtained in this way, especially with the younger embryos than by the more common methods of dissection and clearing in essential oils. The figures of structural details which illustrate the paper were obtained from reconstruction projections of the sections and are magnified twenty diameters. I am not able to state the ages of the various embryos, but this is a matter of little importance since the approximate development can readily be made out from the figures of the various stages, each natural size. The numbering of the separate stages is entirely arbitrary.

I might state here, incidentally, that I have also studied to some extent the foot of the tern and I find in it, as has already been pointed out by other observers, (Miss Johnson, Studer, W. K. Parker and others) a fifth metatarsal present.

Stage I, (Fig. 1).

At this stage (fig. a) the principal elements of the wing are becoming differentiated. The radius and ulna are entirely

cartilaginous, except a small portion at their distal ends where they are least developed. In the proximal row of carpals are two masses of rapidly forming cartilage (radiale and ulnare) each of which appears to have two centers of chondrification.



The larger (the radiale, *re*) is almost divided into two parts; of these the larger and outer one is somewhat triangular in shape and is fitted upon the distal end of the radius, the smaller and inner one is nearly circular and is contiguous to the inner margin of the distal end of the ulna. The ulnare is composed of two oval centers, the proximal being about half the diameter of the distal one, thus giving the whole element a wedge-shaped appearance with its narrow end passing just outside the outer margin of the ulna.

The distal carpals are represented only by a thickening of tissue, or "procartilage" of Parker, showing as yet no differentiation into separate elements. There are *four* radiating digits represented for the most part by "procartilage," but metacarpals II[1] and IV are becoming cartilaginous at their proximal ends and metacarpal III is two-thirds cartilage.

STAGE II, (FIG. 2).

This stage (fig. b) is but slightly more developed than the last. The cartilage is a little more pronounced, and digits II,

[1]For the numbers to be given to the digits, see below.

III and IV have become longer, III and IV being segmented. The fourth digit has become free from the central mass, and more nearly approximated to digit IV. In the distal carpal series there are two masses of cartilage: on the radial side a mass which represents the combined carpales II and III, and on the side of the ulna carpale IV, an oval mass contiguous proximally to the distal lobe of the ulnare and distally to its own metacarpal.

Stage III, (Fig. 3).

In this stage (fig. c) there are several things to be noted. The spreading of the digits is not so great and the whole manus is beginning to flex towards the ulnar side, thereby displacing some of the carpals from their normal position. The elements are now all perfectly distinct, the radiale has entirely lost its bibobate appearance, and is now of an irregular shape, touching the radius and ulna and the approximate surface of the conjoined carpales II and III. The ulnare is now entirely outside the ulna, but, what seems most remarkable, its proximal portion is now about twice the size of its distal lobe, while in the stages previously described it is about half as large. The distal lobe is circular, the proximal wedge-shaped, with the small end proximal. Carpale II+III is the last carpale to chondrify, but is now all cartilage except a very small portion of its proximal end. It is an elongate mass, placed somewhat diagonally to the present axis of the limb. It is contiguous distally to the approximate surface of metacarpals II and III and carpale IV; proximally to the radiale. Carpale IV retains the same relative position as in earlier, except that it has approached closer to metacarpal III. Digits II and III have each added a segment, that of the former is partly cartilaginous, the latter is all procartilage. Metacarpal IV has approached metacarpal III and its single phalanx is entirely cartilaginous. Metacarpal V has the same appearance as in previous stages, but is farther from metacarpal IV.

Stage IV, (Fig. 4).

The specimen which forms the subject of this stage (fig. d) is in some respects slightly more developed than stage III, in

other respects less so. The manus is not flexed so much, and consequently the ulnare has not been pushed so far outside the ulna. In this specimen, unlike the others, the two lobes of the ulnare are about equal in size, the distal one oval, the proximal wedge-shaped. The radiale retains its bilobate appearance as described in stage I. Carpale II+III forms a lunate mass of fully developed cartilage about the head of metacarpal III. Carpale IV is slightly smaller relatively than in the previous stage; the digits are essentially the same.

Stage V, (Fig. 5).

In the specimens (fig. e) which forms the basis of this stage, the manus now assumes very nearly the form which it has in the adult bird. The radiale is irregular in shape and fitted to the distal end of the radius, the inner distale margin of the ulna and the approximate surface of carpal II+III. The distal lobe of the ulnare is here at a minimum in comparison with the proximal lobe; it is now closely appressed to carpale IV which is wedged between it and carpale III. Metacarpal II has approached metacarpale III and on its radial side is developed a large projection or "trochanter." Its proximal phalanx is entirely cartilaginous, its distal one is just beginning to appear. Metacarpal III now bears three phalanges, the distal one not yet cartilaginous. Metacarpal IV has assumed a position parallel to metacarpal III, but is not yet united to it. Metacarpal V has approached metacarpal IV near its proximal end.

Stage VI, (Fig. 6).

In birds of this age (fig. f), carpales II, III and IV have entirely coalesced, and, together with metacarpal II, form a solid socket into which fits the head of metacarpal III. Metacarpal II bears two phalanges; metacarpal III three, their distal phalanges being unequal. Metacarpal V now touches metacarpal IV and is not so near the proximal end as in earlier stages.

Stage VII, (Fig. 7).

There is little in this stage (fig. g) to note except metacarpal V. This is now an oval disk closely applied to the ulnar flexor surface of metacarpal IV, about one-ninth of the distance from the proximal to the distal end. It no doubt finally unites with metacarpal IV at that point.

Comparisons.

Intermedio-Radiale. In Sterna in the earlier stages these two elements are distinct (fig. 1); later they become so completely fused that they cannot be distinguished, although, exceptionally, (fig. 4) they partially retain their individuality for a considerable time. Similar conditions have been noted in several birds, *e. g.*, Opisthocomus, *Fulco tinnunculus* and chick by Parker and *Cypselus melba* by Zehntner ('90). In other birds the separation has not been described, possibly from the fact that the proper stages have not been studied.

Ulnare-Centrale. My observations here closely agree with those of Parker on the ducks and auks, there being the same tendency to subdivision of the cartilage mass into two elements which he shows. One of these is, beyond doubt the ulnare, but I confess I am not so certain of the other which I call centrale in deference to his better opinions. The conditions shown in fig. 1 where the two portions of this element are clearly shown, leads one to the conclusion that the distal lobe may possibly belong to the series of carpales, in which case it would be that of the fourth existing digit. In fig. 5 again the arrangement is such as to support such a view, while on the other hand, in none of the earlier specimens have I seen it in such a position as to indicate that it should be regarded as a centrale. In *Chloëphaga poliocephala* Parker ('90) describes this bone as divided into three portions, the two distal of which he terms centrale 1 and 2. It would rather seem as if we had here to do with a true centrale, while Parker's centrale 1—clearly, according to position, equivalent to the single one which I find—must be regarded as a fourth carpal. (Cf. Parker '90, pl. 5, fig. 14). Studer, according to the

single figure copied by Wiedersheim, has different ideas. He has no such projection from the ulnare, but in his figure carpale I+II projects np between radiale and ulnare and the projecting portion is the centrale. Zehntner, on the other hand, ('90) has the intermedium united to the ulnare, the centrale to the radiale, conditions which certainly do not occur in Sterna.

CARPALS. Unless we regard the "centrale" of the preceding paragraph as in reality a carpal, Sterna never possesses more than two distinct elements in the distal carpal series. Of these that on the radial side is the larger. When chondrification begins it occupies a position (fig. 2) at the base of metacarpal III; later (figs. 3, 4) it extends radially towards metacarpal II, and even at times (fig. 4) exhibits a marked bilobate appearance. From these facts as well as its subsequent history I regard it as a compound body, the carpales II+III of the normal pentadactyle hand, the distal carpal II of Parker and most other students of Avian osteology. Concerning the "pentosteon" of Shufeldt I can say little. This author ('82[b] p. 691, footnote) gives this name to a small bone found by him in Centrocercus lying at the base of the plantar surface of the second (my third) metacarpal. The name was given because it was the fifth carpal bone discovered, and because it was non-committal as to its homologies. Parker now finds the same bone in ducks and auks, occupying the same position, and regards it as carpale I. This interpretation, however, seems to me faulty, as the bone is not in the proper position for such identification, nor have we any torsion or stress which could account for such translation. It would appear rather to belong to the same category as the pisiforme, but since I have not found it in Sterna I can offer no further observations upon it.

The other free carpal element, carpale IV, is clearly but a single element and not a compound structure like that described by Zehntner, Rosenberg and others. Studer, in the penguin, also figures a broad element in this position which he doubtfully regards as compound. In Sterna this element at its first differentiation is no wider than the fourth metacarpal, and as long as it retains its free condition it remains re-

latively of the same size. Later (fig. 6) it becomes united with carpale II+III, the whole forming a single piece equivalent to the separate os magnum and unciforme of some birds.

Metacarpals. The only metacarpal which requires notice is V (IV of many authors). This has been more or less perfectly described by several students since its first discovery by Rosenberg ('73). This author describes it in the chick as a distal process of a common mass of cartilage which clearly contains *two* carpal elements, IV+V, since to it is also joined metacarpal IV. In the case of his figures there can be no doubt that this distal prolongation is a true digital element, as it is clearly homonomous with the other metacarpals. It is to be noted that according to Rosenberg this new metacarpal lies at a lower level than the others, being flexed towards the palmar surface. Zehntner ('90) finds the same element in *Cypselus melba*, but existing there, as in Sterna, as a piece distinct from the basal (carpal) element with which it is at first joined in the chick. According to Zehntner after 9 or 10 days, this metacarpal "geht.... bei Cypselus einen vollständigen Atrophie." This is certainly not the case in Sterna, nor is it in those forms studied by Parker. Here it retains its discrete nature for sometime and in the fowl, toucan and cariama it even becomes ossified before its final union with the basal end of metacarpal IV.

That this is a true metacarpal is, I think beyond question. Owing to the method of study adopted by Parker he failed to recognize its earlier conditions, and his observations, unsupported by other evidence might be interpreted, as has been done by several, in another way. However, the evidence adduced by Rosenberg, Zehntner and myself, clearly removes this from the category of tendinous ossifications, the pisiforme and the like.

Naturally the structures which I have described should be compared with those of the reptiles, but this to be at all adequate would require a detailed knowledge far greater than I possess. It is to be noted, however, that if, as contended in the next section, the avian "pollex" is not the first digit of the pentadactyle hand, a portion of the reasons adduced for

regarding the Pterodactyls as widely removed from the birds is removed.

The Homologies of the Digits.

In the wing of the adult bird only three digits at most attain full development, and, since the birds have descended from pentadactyle forms, it becomes a matter of some importance to compare these three with those of the normal hand; in other words to ascertain which digits have been lost in the process of evolution. Naturally many attempts have been made to solve the problems involved, and within the last decade four different views have had their advocates, though naturally some of these ideas of homology date back to a more remote period.

Thus Gegenbaur ('64), reasoning from the apparent tendency towards reduction of the digital elements on the ulnar side of the crocodilian manus, concludes that the persistent digits of the bird wing are the I, II and III of the normal pentadactyle hand. In this he has had many followers, among them Rosenberg ('73), Huxley ('71), Jeffries ('81), Jackson ('88), and Parker ('88). For this view there are many more arguments than the one mentioned above, and Dr. Jeffries has given an able summary of them.

A second view is that of Owen, according to which the digits in question are II, III and IV. This is based partly ('36) on the fact of the absence of the radial artery, which would indicate reduction on the radial side of the manus; and partly ('62) on features supposed to exist in the British Museum specimen of Archæopteryx. In this there are apparently four digits present in connection with the right wing, but as these show considerable dislocation, one may, as suggested by Professor Owen, have belonged to the other side. This view has fewer supporters than the other, among them Morse and Coues. Morse ('72) contributes not a little in support by his advocacy of the law of digital reduction as a valid argument in this connection. That Coues supports the same view I take partly on the statement of others and partly from the fact that, while in the text of his "Key" ('87), he gives both views, the num-

bering of the digits is II, III, IV. In an earlier paper ('66) he accepts the numbering I, II and III. Here, too, must be enumerated Shufeldt, who states ('82, p. 616) that he has always adhered to this view, but adds "the fact, however, that the first phalanx of the manus of aves is the homologue of the pollex of the pentadactyle limb seems to be gaining ground." I have not found any further reference to this subject in his subsequent osteological contributions further than this usual reference to the radial digit as the pollex.

Mr. Hurst ('93) has advocated a third system of numbering according to which the digits are III, IV and V. An analysis of his reasons will be given immediately when dealing with the arguments for the enumeration adopted in the present paper.

The fourth system is that of Tschan ('89) who according to Zehntner ('90) proposes to regard the permanent digits as I, II and IV. He bases this on the discovery by Parker ('89) of a slip of bone in chick,[2] Musicapa and many Gallinæ as occurring between the second and third of the persisting digits. This, says Tschan, is the true digit III. But Parker further describes similar slips as occurring on the outside of the "pollex" and between the first and second permanent digits as well as a true fourth metacarpal on the ulnar side of the hand. Tschan suggests that the first of these might be the "prepollex" but even with the admission of this doubtful element, there would be one superfluous digit. This together with the utterly anomalous type of reduction which it presupposes—the disappearance of digits in the middle of the manus—is sufficient to discredit this view.

That there is developed a fourth digit in the avian manus is beyond question, and the fact that this comes upon the ulnar side of the three permanent fingers is sufficient to invalidate the nomenclature, III, IV and V of Hurst. Hurst refers to Parker's fourth digit as appearing to be the *os pisiforme,* and since Parker had only the later stages, there would be some plausibility in this view. This possibility, however, disappears

[2]It was discovered, as Parker points out, long before by Heusinger ('20, pl. IV f. 10) in the chick, persisting for sometime as a separate bone.

when we study not only my figures 1 and 2, but the figures of Rosenberg and Zehntner. In the figures just cited the temporary digit is just as prominent as is the "pollex" and no one without a theory to support would regard it other than a digit. Then too, as Rosenberg's figure shows, it bears no connection to the ulnare, but is a distinct outgrowth from the outer distal angle of carpal III+IV.

We are then left to choose between the formulæ I, II and III and II, III, IV, and though the apparent weight of authority is in the other direction, I am strongly inclined towards the second alternative, for the following reasons: First comes the law of digital reduction advocated by Morse, by which in other groups digit I is first to disappear and then V. Further, when further reduction occurs in birds, and a single digit is left as in the Apteryx and the Cassowaries, the reduction has occurred on both sides of the persisting digit, which, according to my nomenclature, would be digit III. This implies a symmetrical reduction, the other view involves the disappearance of digits I, III, IV and V, a condition, so far as I am aware, without parallel.

Then too, Archaeopteryx, in the light of Hurst's later studies presents some evidence. As noted above, Owen thought he had found evidence of a true digit I in the British Museum specimen, but on the discovery of the Berlin specimen this idea was dropped and the conditions presented by the new example form the chief argument in Jeffries' summary already alluded to. It would, however, appear that most recent figures of the Berlin specimen and the conclusions based upon them are not to be relied upon. This can be at once seen by comparing for instance the figure of Archaeopteryx given by Zittel in his Paleontologie with the photographic reproduction which illustrates Hurst's article.[3] In the Berlin specimen three digits in the wing are clearly visible, and it has been assumed that these were the only ones. Hurst, however, points out that the position of the feathers is such that they could not have been borne on these digits as in ordinary birds,

[3] The plate in the Standard Natural History (Vol. IV, facing p. 22, 1885) approaches very closely the figure of Hurst.

but that there must be (at least one) digits buried beneath the feathers, and in just the place where the missing finger or fingers should come is an evident ridge in the stone.

If we may call upon the effects of use and disuse, the conditions presented would also tend to favor the reduction of the digits on the radial side, for it is the ulnar phalanges which must bear the stress of the wing; the fingers on the radial side, having but few small feathers, would be most likely to disappear.

Jeffries invokes also the distribution of the nerves, but to my mind his evidence is not conclusive; besides it is directly negatived by the distribution of the blood vessels as was pointed out above.

We may conclude, then, that the only conditions possible are either I, II and III, or II, III and IV, and that until some evidence be found of the actual appearance of a fifth digit on the ulnar side, that there is at least as much reason for the second as for the first formula. In regard to the first, Hurst remarks, it " is in no case, so far as I am aware, supported by any evidence whatever. I believe it to have originated from the pre-Darwinian statement that the Ala spuria is 'analogous to the thumb;' while the other two digits are called simply 'second' and 'third;' that is, *second and third digits* not of the pentadactyle but *of the tridactyle fore-limb.* Such phrases written on the then undoubted hypothesis of special creation and of fixity of species, could obviously not mean that the three digits called 'thumb' and 'second' and 'third' had been evolved from the digits I, II, III of the pentadactyle fore-limb of an ancestor; the author did not believe that birds ever had such an ancestor. The transcription of such phrases into post-Darwinian treatises, without consideration of the new meaning which they would thus gain from the new context, appears to have been the origin of the error."

Conclusions.

Carpals. There are at least seven elements in the carpus. In the proximal row there are two free elements (intermedio-radiale and centralo-ulnare) both of which are divided in the

early embryo, and represent, morphologically, the radiale, intermedium, centrale and ulnare. In the distal series there are also two free elements, one of them (carpal II+III) being evidently compound.

DIGITS. There are four distinct metacarpals. The first (II) supports two phalanges, the second three, the third one, and the fourth none. The distal phalanges of m. c. II and III are furnished with claws. *M. C.* V arises as a distinct digit, subsequently becomes free, and finally unites with m. c. IV.

NUMBERING OF DIGITS. The persistent digits of the birds wing are either I, II and III or II, III and IV, the bulk of evidence being in favor of the latter enumeration.

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Explanation of the Figures.

The illustrations in the text show the embryos natural size. It is to be noted that fig. A, showing a smaller embryo, had a wing more developed than fig. B. All other figures are projections of camera drawings and are each magnified 22 diameters.

REFERENCE LETTERS.

c carpale
h humerus
r radius
re radiale
m. c. metacarpal.
u ulna.
ue ulnare.
II–IV and I–IV digits.

Fig. 1. Manus, stage I, showing carpus and digits as procartilage with several cartilaginous elements. Digit V is plainly shown.

Fig. 2. Manus, stage II. Three carpals are now seen and metacarpal V has become distinct from the carpal mass.

Fig. 3. Manus, stage III. The digits are now broken into phalanges and the flexure of the hand to the ulnar side is forcing the ulnare out of its normal position.

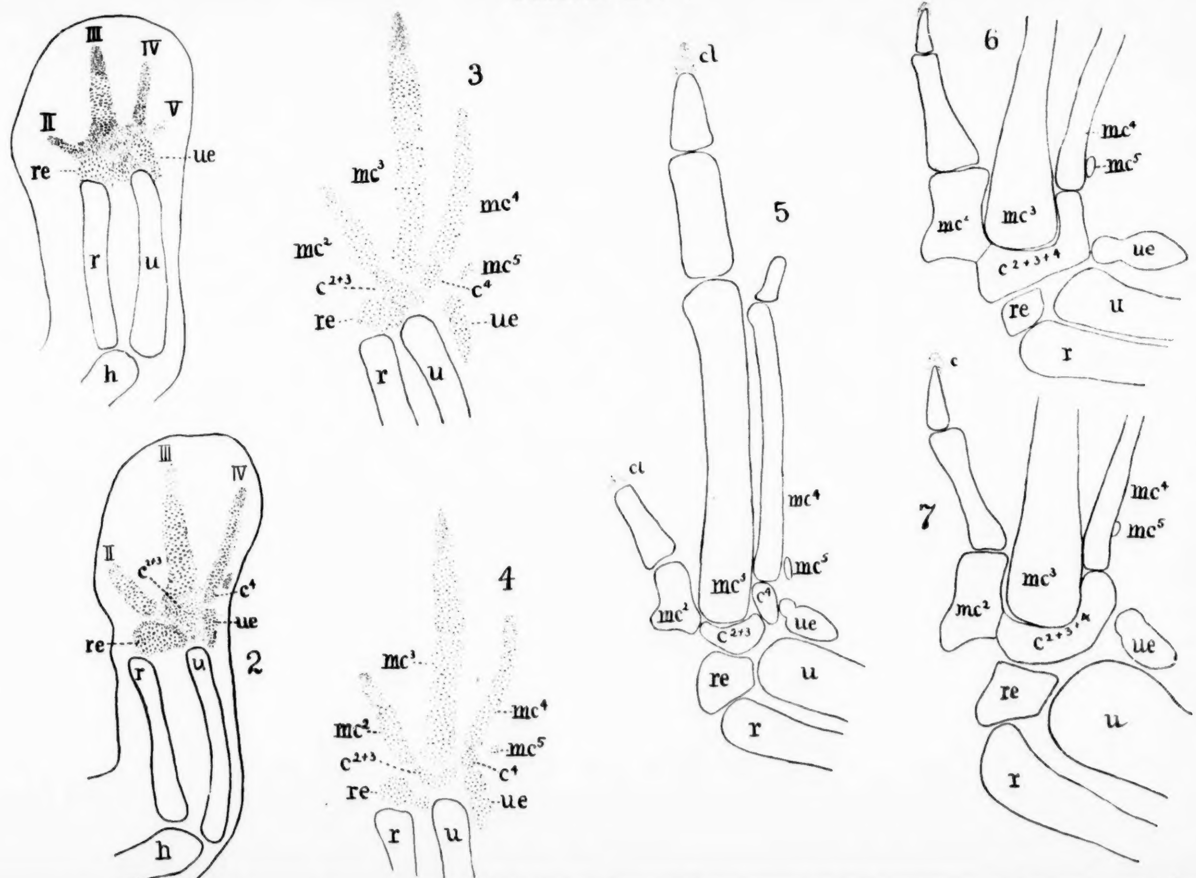
Fig. 4. Manus, stage IV. The radiale shows tendency to division into radiale and intermedium.

Fig. 5. Manus, stage V. Elements now beginning to ossify. Digits II and III are terminated with claws.

Fig. 6. Carpals and metacarpals, stage VI. Carpals united; metacarpal V approximate to metacarpal IV.

Fig. 7. Conditions just before hatching. Metacarpal V joined to metacarpal IV.

PLATE XXV.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A LITTLE KNOWN JAMAICAN NATURALIST, DR. ANTHONY ROBINSON.

By T. D. A. Cockerell.

There are, in the library of the Institute of Jamaica, some interesting old manuscripts, together with a number of drawings which constitute almost the sole record we have of the scientific labors of Dr. Robinson in the island. The drawings are original but the manuscripts are copied from the papers left by the learned doctor, which latter appear to have been lost. The following notice is appended to the copy:

"This [is a] faithfull transcript of Mr. Robinson's loose unconnected and detach'd papers, by Rt. Long, who has revised the whole and corrected the errors of copyist thro-out. Septr., 1769.

"Anthony Robinson, Chirurgeon, formerly of Sunderland by the Sea in Durham, but lately of Jamaica."

In the Jamaica Institute is a pencil drawing of the doctor, by Edward Long, in connection with which Mr. F. Cundall has written the following biographical note:

"Anthony Robinson, surgeon and botanist: a native of Sunderland, England, where he was apprenticed to his father, a surgeon and apothecary: early turned his attention to botany: came to Jamaica: made a collection of several hundred figures and descriptions of Jamaica plants and animals: the drawings are in the Institute of Jamaica, with a copy of the MS. made under the supervision of his friend, Robert Long. (The original MS. is lost). His notes were used by Lunan in his "Hortus Jamaicensis," and by Gosse in his "Naturalist's Sojourn" and "Birds of Jamaica." The House of Assembly voted him £140 in 1767 for his discovery of the method of making soap from the juice of the Coratoe. *d.* 1768." (Journn. Inst. Jamaica, Vol. 1, p. 327).

Although Dr. Robinson did not himself publish, some of his notes have been used by later writers, as stated above. The

greater part of the manuscript, however, is still unpublished, and not long ago it was debated whether the ornithological observations should not be issued by the Institute, accompanied by a selection from the colored drawings. This project after consultation with an experienced ornithologist, was abandoned, at least for the present, as so large a portion of the manuscript consists of elaborate descriptions which would practically duplicate those in existing works. Had these descriptions been published when Dr. Robinson wrote them, their value would have been very different.

The extracts from the manuscript by Gosse in his well known works sufficiently testify to the scientific zeal and knowledge of Dr. Robinson, although his methods were rather those of an age now past. I brought with me from Jamaica copies of several unpublished portions of the manuscript, and will give a few extracts, both to illustrate the character of the man and put on record observations which, although so old, have not lost their value.

1. The Alligator (so-called) of Jamaica, *Crocodilus americanus.* The following selections are from a long account of this animal:

" A very small alligator was put into rum by Mr. Walker, then of Old Harbour, now of Kingston, and according to the nicest reckoning with a watch or other time's measure, liv'd about a quarter of an hour in that spirit."

Of another specimen, "the stomach's contents were bird's feathers (aquatic most probably), joints of crabs claws, and little living white slender worms, with some small pebbles."

The parasitic worms deserve attention; have they been described? In the horned lizard (*Phrynosoma*) of this part of the world (N. Mex.) one finds also such worms.

Dr. Robinson proceeds to describe the crocodile's external features and anatomy: " The guts measuring from the stomach to the end of the intestinum rectum were fifteen feet long, uncoil'd.

" The time the young alligator continued under water was to the outmost but two minutes, as we proved by repeated trials, puddling and disturbing the water in order to keep him under thro' fear as long as his nature would admit.

"He seldom raised more than his nostrils above the water, he ever delv'd at the near approach of any person.

"Taken out of the water, the creature breath'd or made an indraught of air to his lungs, from five to ten slow and regular respirations, and at the end of the fifth, or the tenth time, was a total cessation from breathing for about one minute."

In another place he writes: "Once this animal was observ'd to continue under water upwards of ten minutes.

"I turn'd the alligator on his back and while I staid by him he lay as if lifeless without the least motion, as I observ'd lizards do when turn'd on their backs; I retir'd for about three minutes out of his sight, and on my return he had recover'd his first situation.

"The tail's extreme I caus'd to be broil'd on the creature's dying, and ate of it. The flesh was extremely white, firm, sweet, moist and juicy, as turtle in whiteness but not so dry, not the least musky in taste or smell. My little spaniel dog ate very greedily of it." This alligator was a young one.

The true alligator, it should be remarked, is not found in Jamaica.

2. *Elaps*, probably *E. fulvius;* not Jamaican.

"A snake known by the name of the poison snake among the Indians, but among the Europeans by that of Barber's pole. The Indians have no cure for the bite of this creature, it being mortal in 10 or 15 minutes, the patient bleeding at mouth, eyes, and nose, and thus letting out his life."—(Charles Harris).

"The gentleman who wrote the above is son to Revd. Mr. Harris, late Rector of St. Elizabeth [Jamaica] who was in company with an Indian that died from a bite of the above snake, which he takes to be a species of that received from Walrond Teason, Esq., which came from the Spanish main. I have described it the Ring Snake because its body is surrounded with black and yellow rings. Mr. Harris saw the above on the Moskito shore."

The snake is now commonly called the coral snake, but the title mentioned, "Barber's pole," is more suggestive of its appearance. No poisonous snake inhabits Jamaica.

3. Names of lizards. Dr. Robinson writes Guana uniformily for what is now called the Iguana; and for what Gosse writes Galliwasp (*Celestus occiduus*), Robinson has Gully Wasp. In another place Robinson calls the same lizard Gully Asp, which explains at once the origin of the name. He observes: "The lizard tribe in general have nothing poisonous in their bite, but the Gully Wasp is strongly suspected. Cattle and mules are said to be often bit by them and so swell and die."

This notion reminds one of that current in New Mexico, of the fatal effects of Phasmids on cattle when eaten by them.

4. The Gully Asp, *Celestus occiduus*.

"The Gully Asp inhabits morasses and the banks of rivers, and gullys in the plains and mountains. They live upon fish, fruit and even human excrements. They stand upon the banks of rivers, etc., and watch for the fish coming within reach, when they suddenly spring upon them into the water and bring them out in their mouths to the shore, where they eat them. I have been informed that they are oviparous and lay eggs as big as those of a pullet, but I have not yet seen them. I have often been inform'd that no animal will eat the carcass of this creature, and the following instance seems to prove them unwholesome:

"Dr. David Miller inform'd me that a few days ago an acquaintance of his in his way to Mr. Miller's happen'd to kill a small Gully Wasp of about fifteen inches long and brought him to his house and flung him into an inclos'd square where he kept a young alligator of about five feet long. The alligator immediately swallow'd the Gully Asp. This was about 11 o'clock in the forenoon. About four hours after, the alligator (Robinson writes it aligator) was observ'd to jump and flounce about the square, knocking its head and tail against the stockades, seeming to be quite mad and frantic with pain, and continued in the manner till night, when he died. Therefore, the Dr. concluded that the Gully Asp had poison'd him; he says besides that no creature will touch the dead Gully Asp. it should seem that most animals by a natural instinct shun the carcass, and therefore avoid the certain destruction that would happen to them by eating them.

"Yet I believe it is not the flesh of the Gully Asp that is pernicious for two reasons. First, because the negroes at Egyp(t) Plantation often eat them, and secondly, I cannot think that any of the fleshy part could be dissolved in the cold stomach of the alligator in so short a space of time as four hours, besides the hard scales of the Gully Asp's skin would hinder the digestion not a little. What part of this animal is poisonous? perhaps the viscera, but which? This might be known by giving some creature, as a dog or cat, the different parts of the animal to eat at separate times."

Gosse does not admit that this lizard has any injurious properties. The above anecdote about the alligator (crocodile rather), though interesting, is hardly conclusive by itself. Later, Dr. Robinson writes:

"May the 25th, 1760. I was at St. Tooley's, where the overseer, Mr. Watson inform'd me that the Gully Asps about that estate were very fierce and would seize a man, and that their bite, he assur'd me, was certainly venomous. Memorandum to inquire more strictly into this matter." Later he writes:

"A gentleman in St. Elizabeth's informs me that in the mountains there they have a Gully Asp entirely black, which is said to be poisonous, and that if it bite either man or beast they certainly die. He gave me an instance of one biting a girl on the toe (I think), who expir'd a few hours after receiving it. . . . However, this gentleman and almost all other considerable persons in this parish and the next seem to look upon the Great Morass Gully Asp, which I think it may properly be call'd, as an inoffensive creature; the above-quoted person tells a story of a person who while he slept in the morass one night, laid hold of his cap and endeavour'd to pull it off. The gentleman observing this after the first tug, lay close, and quite mistaking it for a negro, resolving to watch him; and the next pull the Gully Asp gave he laid fast hold of him, but perceiving his error throw him backwards some yards. He says he has often fed them with offal, when he has been eating, and suffer'd them to run over his legs."

5. The following observations on a Cœlenterate which I will not pretend to determine, seem to have a bearing on some quite recently published researches.

"Small, clustering Actinea. Amongst the surrounding rocks of Booby Quay, *Actinia minima viride racemosa*, the clustering small green Actinea. These grew many together, they were about an inch long, of a round form like an earthworm. Their arms extended themselves to the diameter of one's thumb-nail, and nothing could be more pleasing than to lean down and observe some hundreds of these animals with their arms extended in the form of a stellate flower with its disc, which the mouth represents, and its rays the extended arms of a various green color as deeper and paler in circles, supported by deep green pedicels smaller than the fore-quill of a goose, and waving to and fro by the undulating motion of the water.

"From their bases are produc'd young ones, and from thence others which never fall from the mother or parent animal, as in the polypus, by which means, they grow in vast numbers, together so thick as to hide the rocks they grow upon entirely, and may be rais'd up as one body, where their bodies are observ'd to unite to one another. Their bodies are firmer and harder in handling than those of the common Actinea, nor do they shrink so much but only close their arms. They growing upon naked rocks so that they are always visible and taken by the incuriose (sic) to be a kind of sea-moss; at low water many of them are bare, at such times they never disclose or expand their arms."

Perhaps some reader will be able to supply the name of this "Actinea."—Agricultural Experiment Station, Las Cruces, New Mexico, March 4, 1894.

EDITORIALS.

—THE Forty-Third Meeting of the American Association for the Advancement of Science took place in Brooklyn, commencing on August 15. The weather was propitious and members attended to the number of 475. Many meritorious papers were read, and the addresses of the Vice-Presidents presented science in its varied aspects. The introductory address, in reply to the welcome of the citizens of Brooklyn, by the President, Dr. D. G. Brinton, was an admirable exposition of the methods and aims of science. Four lectures were delivered in the evening—the address of the retiring President, Professor Harkness, and three by Messrs Fernow, DuChaillu and Cope. The citizens of Brooklyn entertained the Association with unusual hospitality in the matter of excursions. The neighborhood of New York offers many opportunities in this direction, of which the Association freely availed itself.

The Association has, for several years, missed from its meetings an important contingent of the workers of the country. We refer especially to the anatomists, embryologists and physiologists. The principal object of the Association is to present to the American public an illustration of the work done by the investigators of the country, that they may, in some degree, understand its value. The absence of these gentlemen reduces the value of the Association as an object lesson, and detracts from the force of the impression which the Association should make. Their absence diminishes the prestige of the workers in science in this country. Original research is but little endowed in America, and it is likely to remain so unless the investigators make themselves and their needs known.

The newspapers of Brooklyn gave good reports of the meeting, but those of New York, with some few exceptions, burlesqued the Association. This shows that mental degeneracy is not confined to the rulers of New York, but has gotten a strong hold on the alleged intelligence of the city, viz.: the Press. As New York, however, is not the United States, this matters little, except to New York.

THE tariff bill which has just passed Congress contains the following provisions, which benefit scientific work in this country. The Congressional Committees which have prepared it have been interviewed from time to time by members of the committee appointed for that pur-

pose by the American Association for the Advancement of Science, with the result of placing on the free list the following items: Scientific books and periodicals devoted to original scientific research, and publications issued for their subscribers by scientific and literary associations or academies, or publications of individuals for gratuitous private circulation, and public documents issued by foreign governments; books and pamphlets printed exclusively in languages other than English.

All manufactures of metals not otherwise provided for, reduced from 45 to 35 per cent. ad valorem, or a reduction of 22 per cent.

These provisions almost remove the onerous and disgraceful tax on education and science, which characterized the McKinley bill. It only remains to continue the work, so well begun, of the removing the tax on philosophical apparatus. The Association continued the committee.

THE address of Lord Salisbury at Oxford before the British Association for the Advancement of Science, as its President, is a general review of the present status of selected leading questions in all of the great departments of scientific research. These are treated in a simple and straightforward manner, so as to be fully comprehensible to the lay member. The value of such an address, in informing the public of the nature of the problems which have been solved and are awaiting solution by scientific research, is great. It will also benefit the cause of science in England that so distinguished a member of the ruling class should espouse it in so conspicuous a manner. Lord Salisbury adopts the hypothesis of organic evolution, but, like Lord Kelvin, declines to regard Darwinism as a full exposition of it. Against it he appeals to the evidence of intelligent design to be seen in the organic world. He does not refer to the doctrine of kinetogenesis, which so well explains the nature of design. He is not, however, prepared to accept as a necessary corollary of the fact of evolution, the origin of man from preëxistent Quadrumanas, but calls it "not proven." This is probably as much as we can expect at this time from any one who is not a specialist in biology.

WE understand that among the animals imported from India by W. K. Vanderbilt for his park near Newport, R. I., are several mangooses. It is important that these animals should not escape from confinement, as they will inflict great injury on the native and domesticated fauna should they do so. They multiply rapidly and devour every living thing sufficiently important to serve them as food, whether they live under the ground, on the ground, or at a distance above the ground to

which they can climb. Having no natural enemies in the country, they would become a much greater evil than the English sparrow. Their importation, except for zoological gardens, should be forbidden.

Some industrious persons are endeavoring to utilize parts of the great Palisade dyke of the Hudson for paving-stone. The New York journals are publishing protests against this vandalism, which will, we hope, have the effect of preserving this imposing feature of the scenery of that region.

RECENT BOOKS AND PAMPHLETS.

BATESON, W.—Materials for the Study of Variation, treated with special regard to the discontinuity in the origin of species. London and New York, 1894. From Macmillan and Co. Publishers.

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Bulletin Cornell Univ. Agric. Exp. Station, No. 58, 1893.

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CALVERT, P. P.—Catalogue of the Odonata (Dragon-flies) in the vicinity of Philadelphia, with an Introduction to the Study of this Group of Insects. Extr. Trans. Am. Entom. Soc., Vol. 20, 1893. From the author.

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CROSS, W.—Intrusive Sandstone Dykes in Granite. Extr. Bull. Geol. Soc. Am., Vol. V, 1894. From the Society.

FEDOROFF, E.—Nouvelle méthode pour l'étude goniométrique et optique des cristaux appliquie à la mineralogie et à la pétrographie. Mém. du Comite Géol., Vol. X, 1893. From the Geol. Surv. of Russia.

FLINT, W.—Statistics of Public Libraries in the United States and Canada. Bureau of Ed., Cir. Inform., No. 7, 1893. From the Bureau of Education.

GAGE, S. P.—The Brain of *Diemyctylus viridescens* from Larval to Adult Life, and comparisons with the Brain of Amia and Petromyzon. Extr. Wilder Quarter-Century Book, 1893. From the author.

HAECKEL, E.—Metagenesis und Hypogenesis von *Aurelia aurita.* Ein Beitrag zur Entwickelungsgeschichte und zur Teratologie der Medusen. Jena, 1881.

——Zur Phylogenie der Australischen Fauna. Abdruck aus Semon, Zoologische Forschungsreisen in Australien und dem malayischen Archipel. Jena, 1893. From the author.

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HOWES, G. B.—Notes on the Variation and Development of the Vertebral and Limb-skeleton of the Amphibia.——Notes on the Abnormal Sternium of *Hapale jacchus.* Extrs. Proceeds. London Zool. Soc., 1893.——On the Mammalian Pelvis with especial reference to the young of *Ornithorhynchus anatinus.* Extr. Journ. Anat. and Physiol., Vol. XXVII, 1893. From the author.

LANE, A. C.—Geologic Activity of the Earth's Originally Absorbed Gases. Extr. Bull. Geol. Soc. Am., Vol. V, 1894.

LAWSON, A. C.—The Anorthosytes of the Minnesota Coast of Lake Superior. ——The Laccolite Sills of the Northwest Coast of Lake Superior, with a Prepatory Note on the Norian of the Northwest. Bull. No. 6, 1893. Minn. Geol. and Nat. Hist. Surv. From the Survey.

LINTNER, J. A.—Fourth and Fifth Reports on the Injurious and other Insects of the State of New York. Extr. 41st Rept. New York State Mus. Nat. Hist. From the author.

LOCKWOOD, S.—Some Phenomena in Exuviation by the Reptiles. New York, 1893. From the author.

LUBIN, D. A.—Proposition Revolutionizing the Distribution of Wealth. Sacramento, 1893. From the author.

OSBORN, H. F.—Fossil Mammals from the Upper Cretaceous Beds. Extr. Bull. Am. Mus. Nat. Hist., Vol. V, 1893.——The Rise of the Mammalia in North America. Extr. Proceeds. A. A. A. S., 1893. From the author.

PILLING, J. C.—Bibliography of the Chinookan Languages, including the Chinook Jargon. Washington, 1893. From the Bureau of Ethnology.

SHUFELDT, R. W.—Nesting Habits of *Galeoscoptes carolinensis*. Extr. Auk, 1893.

SIEBENROCK, F.—Zur Osteologie des Hatteria-Kopfes. Aus den Sitzungsb. der kaiserl. Akad. der Wissensch. Wien. Mathem-naturw. Classe, 1893. From the author.

SMITH, E. F.—Experiments with Fertilizers for the Prevention and Cure of Peach Yellows, 1889-92. Bull. No. 4. U. S. Dept. Agric. Div. Veg. Path., Washington, 1893. From the Dept. Agric.

SMITH, J. B.—Catalogue of the Lepidopterous Superfamily Noctuidae found in Boreal America. Bull. U. S. Natl. Mus. No. 44, 1893. From the Smithsonian Institution.

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TARR, R. S.—Economic Geology of the United States. New York, 1894. Macmillan and Co., Pub. From John Wanamaker's.

TOPINARD, P.—L'Anthropologie aux Etats Unis. Extr. de l'Anthropol., 1893.

TRAQUAIR, R. H.—On *Cephalaspis magnifica*.——Achanarras revisited. Extrs. Proceeds. Roy. Phy. Soc. Edinburgh, Vol. XII. From the author.

TSCHERNYSCHEW, TH.—Die Fauna des unteren Devon am Ostabhange des Ural. Mém. du Comité Geol., Vol. IV, 1893. From the Geol. Surv. of Russia.

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——AND EARLE, C.—Ancestors of the Tapir from the Lower Miocene of Dakota. Extrs. Bull. Am. Mus. Nat. Hist., Vol. V, 1893. From the author.

ZITTEL, K. A. VON—Die geologische Entwickelung, Herkunft und Verbreitung der Säugethiere. Aus den Sitzungsb. der math.-phy. Classe der k. bayer Akad. d. Wiss., 1893. Bd. XXIII. From the author.

RECENT LITERATURE.

Louis Agassiz: His Life and Work; by Chas. Frederick Holder, M. D.[1] In this volume we have an appreciative history of Agassiz, in which the characteristics of the man, and the nature and progress of his work are most happily woven together. His ambitions, while still under the parental roof in Neuchatel, are recounted, and his biographer shows how early the dominant bias of a man's life may appear. We are told how his persevering devotion to his favorite pursuit did not prevent him from preparing for the practice of the medical profession, as a means of livelihood; and how, later, the opportunity of studying and reporting on the fishes brought home by Von Martius from Brazil, determined his future course. Every naturalist has been introduced to his life work in the science by especial facilities enjoyed for the study of some particular group. To Agassiz this group was the fishes, and his first works after that on the fishes of Brazil, were those on the fresh-water fishes of Europe, and the Fossil Fishes. But his highly appreciative mind was directed to all the problems offered by nature to human thought, and he quickly saw the importance which attached to the study of the Swiss glaciers. The far-reaching results of this work are now common knowledge; as it contains the key to the superficial geology of the temperate regions of the earth. The application of the glacial phenomena in geology is Agassiz's greatest achievement.

The history of Agassiz's work in the United States is interestingly told, and the narration of the Brazilian expedition is charming. The volume closes with a reprint of some of the memorials which expressed the feelings of naturalists at the time of his death, and with a bibliography.

The work is handsomely illustrated, largely from photographs made during the Brazilian expedition. It is a pity that better figures of the Brazilian fishes and turtles could not have been copied, as those in this book are mostly bad.

The personal characteristics of Agassiz are pleasantly described, and for this reason among others the book will be a valued souvenir to the friends who knew him. The author dwells especially on his great mer-

[1] 8vo, pp. 327, illustrated. G. P. Putnam's Sons, New York and London, 1893.

its as a teacher, which, indeed, cannot be exaggerated. He greatly popularized the pursuit of science in America, and the effect of his life and labors in this direction has been greater than that of any man, probably of many men. The pursuit of science was to him, as it should be to all, a duty undertaken for the elevation of human thought. That the visible nature is the material expression of the thoughts of God, was Agassiz's oft expressed belief. Doubtless he was correct, but the proof of it comes in a way different from that which this great naturalist anticipated; that is, through the direction of evolutionary descent. Perhaps if Agassiz had lived longer, he would have adopted this view, and embellished it as he did all his teachings.—C.

Nuttall's Ornithology.[2]—This hand-book of ornithology is published in two handsome volumes 8vo, of some 400 pp. each. It is practically a new edition of Nuttall's Manual, which has been out of print for several years, to which the editor has added brief notes relating the results of recent determinations in distribution and habits. The introduction is given exactly as it appeared in Nuttall's second edition, and the text of the biographical matter has been changed but little. To this Mr. Chamberlain adds a description of the plumage, nest and eggs of each species.

In his treatment of the subject, the author covers the entire area of the Eastern Faunal Province from the Gulf of Mexico to the Arctic Ocean. The nomenclature adopted is that of the Check List issued by the American Ornithologists' Union. The illustrations are mostly drawn especially for the work. They are of excellent quality and are of size appropriate to that of the pages.

Nuttall's Manual was for a long time the only text-book of American ornithology available to pockets of limited resources. Its style and treatment of the subject are most attractive, and it has probably done more to diffuse a knowledge of the subject than any other work. Boys read it who had access to no other, and many naturalists of to-day date their interest in their science to the charm of its pages. Although the excellent works of Coues and Ridgway have made us better acquainted with the science of ornithology, nothing has superseded Nuttall's work as a delineator of habits and manners of birds. It was a happy thought that resulted in the publication of this new edition under Mr. Chamberlain's editorship.

[2] A Popular Hand-book of the Ornithology of the United States and Canada, based on Nuttall's Manual. By Montague Chamberlain. Boston: Little, Brown & Co., 1891.

Seeley on the Fossil Reptiles : II. Pareiasaurus ; VI. The Anomodontia and their Allies ; VII. Further Observations on Pariasaurus.[3]—Professor H. G. Seeley has again made the scientific world his debtors by his descriptions of new forms of South African fossil reptiles; by his extensive comparisons of the characters of these, the oldest known members of the class; and by his very full study of that remarkable form, the Pariasaurus of Owen. These works are valuable to students of the Reptilia of corresponding age in other parts of the world, and especially to those of the American forms. The descriptions are elucidated by cuts and plates.

Prof. Seeley has shown that the genus Pareisaurus is allied to the American Diadectidæ, and that it represents a distinct family of the same order, the Cotylosauria. His proposition of a new ordinal name, Pariasauria, is perhaps due to the fact that the original definition of the Cotylosauria was defective in one respect. The corrected definition was published later, and in the same year as the proposal of the new name by Dr. Seeley.

Several important points of both anatomy and taxonomy are presented in these memoirs, on which I propose to touch. In the first place, no one had, at the time that these memoirs were written, distinguished between roof-bones and the bones of the brain case, in the Reptilia. Although the two series are to be entirely distinguished in all vertebrates which possess them, the same names have been used variously for opposite or adjacent elements of both. The names squamosal, epiotic and opisthotic have thus been used in double senses. For the posterior bones of the temporal roof I have adopted the terms zygomatic, supratemporal, supramastoid[4] and tabulare.[5] The supratemporal is called squamosal by Seeley. But the squamosal is a bone of the lateral wall of the brain case, and cannot be identified with any one of the three possible post-orbital bars of the Reptilia, which may be composed posteriorly of either the zygomatic, supratemporal or supramastoid. The epiotic of Seely and of some others is the tabulare m., and has nothing to do with the original epiotic of Huxley.

Prof. Seeley describes the Placodontia as possessing two occipital condyles, which have the position of zygapophysial articulations. The basioccipital he describes as presenting " a thin film of bone " posteriorly on the middle line. Perhaps the basioccipital bone with its con-

[3] From the Philosoph. Transac. Royal Society of London, 1888, p. 59; 1889, p. 215, and 1892, p. 311. Illustrated.

[4] Transac. Amer. Philosoph. Soc., 1892, 11.

[5] Proceeds. Amer. Philosoph. Soc., 1894, 110.

dyle is caducous, as it is in the Diadectidæ, and has been lost from the specimens Dr. Seely has examined. It is this peculiarity that led me into error in my first diagnosis of the Cotylosauria.

Prof. Seeley makes quite full comparisons with the forms of the American Permian. He seems impressed with reptilian affinities in Eryops. But this genus is a true Stegocephal in every respect, and has no greater affinity with the Cotylosauria than any other member of the order. In quoting my description of the tarsus of the Clepsydropidæ, he falls into error in stating that I allege that "the tibials and centrals united to form an astragalus." I have stated that the intermedium and centrals unite to form the astragalus. He also states that I have not figured the intercentra of the Pelycosauria. He will find that my figures of Clepsydrops and Dimetrodon represent them.

Dr. Seeley shows that the structure of the vertebral column and pelvic arch have a close similarity in the Cotylosauria, Anomodontia and Theriodonta of South Africa. I have discovered the same characters of these regions in the Cotylosauria and Pelycosauria of North America. For the order which is to include these divisions, Seeley, like Lydekker, retains the name of Anomodontia of Owen. But Owen originally proposed this name for the group which includes the genera Oudenodon, Dicynodon and Lystrosaurus (Ptychognathus Owen). Further, in his work of 1876[6] on these reptiles, he continued this use of the name, making it of equal rank with the Theriodonta. It being evident that the entire division required a name, I gave it that of Theromorpha (Proceed. Amer. Philosoph. Soc., 1880, p. 38); (subsequently altered to Theromora, on account of preoccupation.) The use of the name Anomodontia for this order has no support in the rules of nomenclature.

Dr. Seeley discusses the possible relation of the Pelycosauria of the American beds with the African Theriodonta. There are important resemblances between these groups. Unfortunately, corresponding parts of the two are in several cases unknown. Thus the shoulder girdle and tarsus of the Theriodonta have not been yet obtained. Until these lacunæ are made good we cannot determine the mutual affinities of the two. We naturally look to Prof. Seeley for more light on this subject. It is possible, also, as I have suggested, that the postorbital arch of the Theriodonta is the superior arch (supratemporal), and not the inferior arch (zygomatic), as in the Pelycosauria.

NOTE.—In my paper on the Plesiosaurian skull (Proceeds. Amer. Philos. Soc., 1894, p. 111, line 10), by a lapsus calami, I wrote Proterosauria for

[6] Description of the Fossil Reptilia of South Africa in the British Museum.

Procolophonina. In my paper on the postorbital bars of Reptilia (Trans. Amer. Philos. Soc., 1892, p. 16, bottom) I refer to the postorbital bar of the Theriodonta, meaning the Pelycosauria. This is due to the premature assumption by English authors, to which I at the moment assented, that the two groups are identical.—E. D. COPE.

Scott on the Mammalia of the Deep River Beds.[7]—In this handsome memoir of 130 pages we have recorded the results of the Princeton College expedition of 1891. The region explored is the valley of Deep River, one of the upper tributaries of the Missouri in Montana. This formation was observed to contain fossils by Grinnell and Dana in 1875, and was explored by a party sent by the present reviewer in 1878. The latter reported from it twelve species of Mammalia all of which were new except a Prothippus of Loup Fork age, and a Protolabis of uncertain species. The Princeton expedition obtained twenty-two species, of which eight are new to science. Prof. Scott prefers to call this formation by the name of Deep River, rather than the Ticholeptus bed, as it was originally named by Cope. This is because the name Ticholeptus, as a paleontological term, is a synonym of Merychyus. However, as applied to a formation, it was not preoccupied, and it is doubtful whether, under the rules, it can be changed.

The new forms belong to the following orders : Carnivora, 2 ; Glires, 1 ; Perissodactyla, 2 . Artiodactyla, 3. The most important addition to the Carnivora is a new genus of Canidæ, Desmatocyon, which agrees with Canis, except in the possession of three longitudinal convolutions of the cerebral hemispheres. The Glires are represented by a new Steneofiber. The most important novelties are two species of three-toed horses, which are named respectively *Desmatippus crenidens* and *Anchitherium equinum*, the latter the largest known American species of its genus. Prof. Scott takes occasion to present a new classification of the genera of American three-toed horses, distinguishing four genera in species formerly referred to Anchitherium. These are Mesohippus, Miohippus, Desmatippus (nov.) and Anchitherium. Scott has already shown that Mesohippus differs from the other genera in the absence of pits of the incisors, and he assumes that Miohippus, named but not distinguished by Marsh, possesses those pits, although he states that its upper incisors are not known. I can state that this supposition is perfectly correct, as they are present in the species I have called *Anchi-*

[7] From the Transactions of the American Philosophicel Society, 1894, Vol. XVII, p. 55.

therium equiceps, *A. longicriste* and *A. praestans*, from the John Day Beds of Oregon, the horizon of Miohippus. The separation of Miohippus from Anchitherium is proposed by Prof. Scott, on the relative size of the conules of the molars, on the form of the external face of their external wall, and on the separation or confluence of the posterior transverse crest with the latter. The first two characters do not appear to me to be of generic value, while the third is probably a valid one. On this basis the John Day *Anchitheria equiceps*, *brachylophum*, and *longicriste* must be referred to Miohippus, while *A. praestans* is an Anchitherium. That is, supposing Marsh's type of Miohippus possess the character referred to, which is unknown. The same character will refer Desmathippus to Anchitherium; and the other characters regarded by Prof. Scott as distinguishing the two, do not seem to the reviewer to be of sufficient value to forbid such reference.

The *Anchitherium crenidens* (as we would call it) presents especial interest in the strong crenation of the anterior border of the metaconule, offering the earliest example of this structure known, and pointing to the origin of the similar structure seen in later horses of several genera. In the *A. equinum* we have the American form nearest to the European *A. aurelianeuse*. The American (White River) *A. exoletum* Cope (not *A. cuneatum*, as stated by Scott) has superior molars of similar character.

In the Artiodactyla, the most important discovery is the presence of an ossified thyroid cartilage, and a probable rudimental clavicle in an Oreodontid, which but for these characters would be an Eporeodon. To this form Prof. Scott gives the name of Mesoreodon.

We expect thorough and intelligent work from Prof. Scott, and in this memoir we are not disappointed. It is by papers of this kind that our knowledge of the evolution of organic life is really advanced. The illustrations are every way worthy of the text.—E. D. Cope.

Von Ihring on the Fishes and Mammals of Rio Grande do Sul.[8]—These two brochures are valuable as bringing the subject of which they treat up to a later date than the papers of Hensel, who wrote in 1870–2–9. The species are not all described, and some of the notices embrace descriptions of habits, while the known distribution is given, with pretty full references to the literature. The species of

[8] Die Süsswasser Fische von Rio Grande do Sul; von Dr. H. von Ihring, 12mo, 36 pp.; Rio Grande, Jan. 1893.

Os Mammiferos do Rio Grande do Sol, pelo Dr. Herman von Ihring, 12mo, pp. 30; Rio Grande, Apl. 20, 1892.

fishes enumerated are chiefly those of the Atlantic streams. They are included in the following orders: Nematognathi, 23 sp.; Plectospondyli, 14 sp.; Holostomi, 1 sp.; Percomorphi, 8. A new Gobius is described. The Mammalia number 92 species, of which 11 are Marsupialia, 5 Edentata, 23 Glires, 16 Chiroptera, 20 Carnivora, 17 Diplarthra, 3 Quadrumana, and 2 Cetacea. An interesting feature is the number of species of Didelphyidae, of which a new species is described. The author includes without hesitation the *Felis braccata* Cope in the *F. jaguarondi*, probably because in the original description it is said to be allied to that species. As matter of fact, however, it is very little allied to that species, and has no close relationships to any other. It is remarkable for the large size and pointed outline of its ears, which are sharply bicolor on the upper surface. The mounted skin shows faint oblique bands on the sides. Its very obscure colors render it easy of concealment, which, perhaps, with its apparent rarity, accounts for its having so long escaped the observation of naturalists. Von Ihring also asserts the identity of the *Sphingurus sericeus* with the *S. villosus*. If the latter is, as generally asserted, identical with the *S. insidiosus*, the *S. sericeus* is distinct enough.—E. D. Cope.

General Notes.

GEOLOGY AND PALEONTOLOGY.

Geologic Time indicated by the Sedimentary Rocks of North America.—Various geologists have speculated as to the age of the earth, basing their estimates on both geologic and paleontologic data. The latest contribution to the subject is from Dr. Charles Walcott. His unit is the age of the Paleozoic rocks of the Cordilleran area in western North America. A careful consideration of all the factors of denudation and deposition leads him to consider that it would have required 17,500,000 years for the deposition of the calcium and the mechanical sediments of Paleozoic time. He concludes his paper as follows:

"Taking as a basis 17,500,000 years for Paleozoic time, and the time ratios 12, 5 and 2 for Paleozoic, Mesozoic and Cenozoic (including Plistocene) respectively, the Mesozoic is given a time duration of 7,240,000 years, the Cenozoic of 2,900,000 years, and the entire series of fossiliferous sedimentary rocks of 27,650,000 years. To this there is to be added the entire period in which all of the sediments were deposited between the basal crystalline archean complex and the base of the Paleozoic. Notwithstanding the immense accumulation of mechanical sediments in this Algonkian time, with their great unconformities and the great differentiation of life at the beginning of Paleozoic time, I am not willing, with our present information, to assign a greater period than that of the Paleozoic—or 17,500,000 years. Even this seems excessive. Adding to it the time period of the fossiliferous sedimentary rocks, the result is 45,150,000 years for post-Archean time. Of the duration of Archean or pre-Algonkian time, I have no estimate based on a study of Archean strata to offer. If we assume Houghton's estimate of 33 per cent. for the Azoic period and 67 per cent. for the sedimentary rocks, Archean time would be represented by the period of 22,250,000 years.

"In estimating for the Archean, Houghton included a large series of strata that are now placed in the Algonkian of the Proterozoic of the U. S. Geol. Survey; and I think that his estimate is more than one-half too large; if so, ten million years would be a fair estimate, or rather conjecture, for Archean time.

Period.	Time Duration.
Cenozoic, including Pleistocene	2,900,000 years.
Mesozoic,	7,240,000 "
Paleozoic,	17,500,000 "
Algonkian,	17,500,000 "
Archean,	10,000,000(?) "

"It is easy to vary these results by assuming different values for area and rate of denudation, the rate of deposition of carbonate of lime, etc.; but there remains, after each attempt I have made that was based on any reliable facts of thickness, extent and character of strata, a result that does not pass below 25,000,000 to 30,000,000 as a minimim and 60,000,000 to 70,000,000 as a maximum for post-Archean geologic time. I have not referred to the rate of development of life, as that is virtually controlled by conditions of environment."

"In conclusion, geologic time is of great but not of indefinite duration. I believe that it can be measured by tens of millions, but not by single millions or hundreds of millions of years." (Journ. Geol., Vol. I, 1893.)

For the latest estimates as to the duration of the Glacial period see American Naturalist, March, 1894, p. 263.

The Lignites of Southern Chili.—After having made a field study of the lignitic formation in the southern part of Chili, M. Noguès reports to the Société Scientifique of Chili that these lignites certainly do not belong to the Permo-carboniferous age, as has been stated, but are of a much later age. They constitute a long band extending in a north and south direction, parallel with the Pacific Ocean, and have been dislocated by a complex series of faults. M. Noguès extended his observations to the schisto-arenaceous system, which is found around the river Bio-Bio and its affluents, La Quilacoya and the Rio Grande, and which contains beds of true anthracite coal. Paleontological evidence shows that this system corresponds with the lower beds of the lignitic formation above mentioned. Like the lignite, also, it rests unconformably upon granite rocks and the old schists of the Cordilleras, and been subjected to movements which have produced folds, swellings and anticlinals. (Actes de la Soc. Sci. du Chili, Santiago, 1894.)

Lower Cretaceous Fossils from the Black Hills of Dakota.—A recent find of cycadean trunks near Hot Springs, South Dakota, led Mr. Lester Ward to investigate that locality with the view

of determining the stratigraphical position of the beds in which the fossils occur. The whole of this region consists of a series of sandstones that have been treated in the Black Hills report as the "Dakota Group." In examining a locality two miles west of Minnekahta Creek, Mr. Ward found, interstratified with the sandstones, some argillaceous shales containing a fossil flora of ferns, coniferous twigs and cycadean remains, which the author refers to the Lower Cretaceous. A further study of the plants by Prof. Fontaine and Prof. Knowlton confirms this reference. Between the horizon where these fossils were found and that of the true Dakota Group there are some hundreds of feet of sandstone and shales. (Journ. Geol., Vol. II, 1894.)

Lower Eocene Mammals near Lyons, France.—A preliminary note published by M. Charles Deperet in Comptes Rendus, April, 1894, states that a remarkably rich deposit of Eocene Vertebrates has been discovered in a quarry at Lissien, near Lyon. The author proposes to make these fossils the subject of a special memoir, but meanwhile, he gives the following brief summary of the most important facts:

"The [Perissodactyla] are the most numerous. At the head of the list stands Lophiodon, represented by three forms: one, having molars of the type named by M. Rütimeyer, *L. rhinoceroides*, but the body not quite so large. A second species resembles in form *L. isselense*, but is distinguished by its inferior premolors which have the cingulum very attenuated, recalling in this particular *L. cuvieri* of Jouey. The third form has a large premolar furnished with a rudimentary internal posterior cusp, as in *L. lautricense*.

"The American genus Hyrachyus is represented by a type that I believe to be identical with *Lophiodon cartieri* Egerkingen, and also a species of Argenton, named by M. Filhol *Hyrachyus intermedius*.

"The group [Lophiodontidae] is still more abundant. I can only mention two Paloplotheria, one large (*P. magnum* Rütimeyer), the other hardly larger than *P. codiciense* Gaud. to which it is evidently related, from the structure of the premolars.

"The genus Propalaeotherium is represented by two species, one large, indentical with *P. isselanum* Cuv.; the other small, suggesting *P. minutum* Egerkingen. A small Anchilopus seems to be related to *A. desmarestii* Gerv. Finally, there are some inferior molars which correspond to those of the ill-defined genus Lophiotherium Gerv.

"Among the Artiodactyla I have noticed the molars of *Acotherulum saturninum* Gerv., and one fine demi-mandible of a Dichobune smaller than *D. leporinum*.

"Of the group of primitive ruminants, there are only some molar teeth which seem to be identical with *Dichodon cartierii* Egerkingen.

"But the most interesting discovery among the Ungulates is a single upper molar, differing only by its smaller size from that of the animal of Egerkingen, referred by Rütimeyer to the American genus Phenacodus, under the name *P. europæus.*

"The Carnivora are represented by several types, among others a Pterodon, a primitive Viverra, with the heel of the sectorial tooth very short, as in *V. angustidens.*

"Finally, of the group of rodents, there is a fine demi-mandible of a Sciuroides, related to *Sc. siderolithicus* of Egerkingen.

"Among the undetermined species are some bones of Birds and Reptiles."

Geological News, Paleozoic.—According to Mr. C. Schuchert, a collection of fossils, comprising about thirty species, most of which are corals, demonstrate the undoubted presence of middle Devonian deposits in northern California. All the fossils studied are from limestone, nothing as yet being known from a sandstone or shale fauna.

The localities in which these collections were obtained have been examined by Mr. J. S. Diller. They are in Shasta and Siskiyou counties, California, and as the general strike of Devonian rocks near Kennett is in a line with outcrops of Hazel Creek and Soda Creek, over thirty miles away, it is thought that these rocks may be continuous. This would be an additional evidence for Mr. Diller's theory previously stated "that the axis of folding joins the Klamath Mountains to the Coast Range rather than to the Sierra." (Am. Journ. Sci., June, 1894.)

Dr. Ludwig von Ammon has published a memoir on the Stegocephali of the Rhein-pfalz known to him. These include nine species which are referred to the following genera: Branchiosaurus, 2; Apateon, 1; Anthracosaurus, 1 sp.; Archegosaurus, 2 sp.; Sclerocephalus, 2 sp.; Macromerium, n. g. von Ammon, 1 sp. The most abundant remains belong to Sclerocephalus, which includes also the the largest species. *Macromerium gumbelii* von Amm. was also a large species. The memoir (published at Munich) is in 4to, and is handsomely illustrated.

Dr. Hermann Credner published in the XXth Volume of the Abhandlungen of the Royal Saxon Society of Science a beautifully illustrated memoir on the histology of the teeth of the Paleozoic Stegocephali with plicate dentition. The investigation is confined to the

genus Sclerocephalus. By removal of the osseous structure, Credner obtains beautiful casts of the vascular structures of the teeth. From this study Dr. Credner concludes that the large teeth of the Stegocephali are formed by the fusion of small teeth, such as are frequently present on the palatine and splenial bones of these animals.

Mesozoic.—The eastern boundary of the Connecticut Triassic is defined, according to Messrs. Davis and Griswold, by fault-lines—a combination of several intersecting faults, rather than a single irregular fault. The inferred faults may be divided into two sets, those of one set trending about north and south, and represented by three members; those of the other set trending northeast and northwest, and including two members. All five faults are believed to extend beyond the parts of the border line that they determine into the area of the crystalline or Triassic rocks. (Bull. Geol. Soc. Ann., Vol. V, 1894.)

In a paper in the Journal of the Philadelphia Academy, Prof. Cope describes several Pycnodont fishes from the Wichita Cretaceous bed of western Oklahoma, and a Lepidotid from the Trinity formation of Texas. He also describes part of a tarsometatarse of a bird from a probable neocene bed of Vancouver Island, under the name of *Cyphornis magnus*. He thinks it is allied to the Pelicans, but the bone is as large as the corresponding part of the American Ostrich.

A collection of Neocomian invertebrates from Kansas yields upon examination 17 new and 4 rare species. Among them is a large, apparently nereid, worm, and a well-preserved specimen of *Trochus texanus* Roem. The fossils are described and figured by Prof. F. W. Cragin in the Am. Geol., Vol. XIV, 1894. Prof. Cragin also reports from the same formation two new reptiles, *Pleisiosaurus mudgei* and *Plesiochelys belviderensis;* and three fishes hitherto undescribed, *Mesodon abrasus*, (*? Lamna*) *quinquilateralis* and *Hybodus clarkensis*. (Fifth Ann. Pub. Col. Sci. Soc., 1894.)

Cenozoic.—In the fourth part of the "Materiaux pour l'Histoire des Temps Quaternaires," MM. Gaudry and Boule describe bones of Mammalia from the caves of Gorgas in the Hautes Pyrenées. They found there *Ursus spelaeus*, *Crocuta maculata spelaea*, and *Canis lupus*. They embrace the opportunity of showing the graduated dentition of the Canidae from Canis through Hemicyon and Hyaenarctus, of which they give instructive figures.

M. Harlé calls attention to the discovery of fossil Hyaenas of the striped type, in the grotto of Montsaunès (Haute-Garonne). With the exception of a specimen found in the grotto of Lunel-Viel by Marcel, at the beginning of this century, there is no record of this Hyaena having ever been found in a cave in France. (Comptes-Rendus, Paris, 1894.)

Professor Dames, of Berlin, describes some remains of a Zeuglodon from Fayoum in Egypt in the Paleontological Abhandlungen for 1894. They consist of a left mandibular ramus and vertebrae of a species of medium size, which he regards as belonging to a species previously unknown. He calls it *Z. osiris*. He makes some suggestions as to the systematic of the Cetacea, proposing to divide the order primarily on the characters of the teeth. This view will not, however, probably replace the customary one, which regards as of more importance the skeletal characters of the Archæroceti, and relegates the dentition to a place of secondary value.

Dr. G. Capellini had added much to our knowledge of the extinct Cetacea of Italy in a number of illustrated papers. He describes several species of Ziphius and Mesoplodon, some of which are new; a Delphinoid with a long muzzle; a Tursiops; and the *Balæna etrusca* Cap. He also describes the remains of a new Halitherium (Metaxytherium), and a crocodile with a slender muzzle, which he refers to the genus Tomistoma, under the name of *T. calaritanum* Cap. The latter is represented by a fine skull, and some vertebræ and dermal scuta, and other important pieces.

PETROGRAPY.[1]

In a long and extensive article, Mügge[2] treats of the keratophyres of the Lennethal in Westphalia, and the neighboring regions, and their tuffs. The rocks have been considered as fragmental schists by some observers and as squeezed eruptives by others. They are known generally as the Lenneporphyries. Mügge finds that some of them are genuine eruptives and some are the tuffs of these. The massive rocks are keratophyres and quartz-keratophyres, sometimes carrying large phenocrysts of quartz and feldspar and at other times free from these. The groundmass of the keratophyres is made up of bleached biotite, sericite, feldspar, opal and glass, with traces of spherulitic structure. Schistose varieties of the quartzose varieties have become foliated through pressure, as shown by the fractured quartzes and feldspars that occur so abundantly in them, the presence of lenticular areas of quartz mosaic and the greater abundance of sericite. The most characteristic of the lenneporphyries are tuffs in which the ash structure is very well exhibit. The typical tuff structure is described by the author as due to the accumulation of glass particles with concave boundaries. These are mingled with complete and broken crystals of various minerals and often with sedimentary material. Rocks composed of intermingled volcanic and sedimentary fragmental material the author would call tuffites; when metamorphosed, tuffoids. Many of the rocks in the Lenne district have suffered dynamic metamorphism with the production of secondary quartz, feldspar, sericite, carbonates and chlorite. They are, therefore, tuffoids. The new material was formed partially from the decomposition of the rock's materials and partially with the aid of alkaline solutions originating outside of the metamorphised rocks.

Nepheline-Melilite Rocks of Texas.—Osann[3] finds a melilite nepheline basalt occurring as dykes in the Cretaceous of Uvalde Co., Texas, and nepheline basanites forming buttes and hills in the same region. The basalts are typical melilite varieties, containing phenocrysts of olivine and micro-porphyritic crystals of melilite with all the characteristic features of this mineral. Perofskite is a common

[1]Edited by Dr. W. S. Bayley, Colby University, Waterville. Me.
[2]Neues Jahrb. f. Min., etc. B. B. viii, p. 525.
[3]Jour. Geol., Vol. I, p. 341.

accompaniment of the melilite. The basanites have an andesitic habit and since they contain more or less sanidine, they approach phonolite in composition. Hornblendes, two monoclinic augites and nepheline are common as phenocrysts, while sanidine, plagioclase and olivine are scarce. The rock of Pilot Knob, near Austin, is a porphyritic nepheline basalt.

Eleolite Syenite from Eastern Ontario.—Adams,[4] while making a geological reconnaissance in the township of Dungannon, Ontario, discovered a large area of eleolite syenite in the Laurentian of the region. The rock is notable especially for the fresh scapolite and calcite present in it and for the fact that its feldspathic constituent is an albite. Petrographically the syenite is an aggregate of the minerals above mentioned and hornblende, biotite, sodalite, garnet and zircon. The nepheline is fresh. It occurs in large quantity, and sometimes in individuals two and a half feet in length. Its composition according to Harrington is

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Loss	Total
43.51	33.78	.15	.16	tr	5.40	16.94	.40 =	100.34

The mica is a dark yellow-brown variety. It is present in small quantities only. Hornblende is also comparatively rare. It occurs in two varieties in different specimens. One variety has a large optical angle and a pleochroism of deep green and pale yellow tints. The other is allied to arfvedsonite. It has a small axial angle, and is pleochroic in deep bluish-green and yellowish-green tints. The scapolite is in large colorless grains that are fresh and seem to be original, and the calcite in more or less rounded individuals, often included within the other constituents. The feldspar is largely albite. A small quanitity orothoclase occurs, especially associated with the sodalite. This orothoclase is thought to be secondary.[5] An analysis of the sodalite gave:

SiO_2	Al_2O_3	FeO	Na_2O	K_2O	Cl	SO_3	H_2O	Ins.	Total
36.58	31.05	.20	24.81	.79	6.88	.12	.27	.80 =	101.50

O = Cl 1.55 = 99.95.

Petrographical News.—The basic dyke material at Hamburg, Sussex Co., N. J., which was thought to be leucite tephrite by Hus-

[4]Amer. Jour. Sci., 1894, XLVIII, p. 10.

[5]Cf. also Geol. Surv. of Can., Vol. VI, Pt. J.

sak[6] and declared by Kemp[7] to be an aggregate of pyroxene, biotite and analcite has been examined at another place by the last named geologist. It has been found by him[8] to contain leucite. Hussak's determination is thus confirmed. The rock is a leucite tephrite.

A spherical granite from a boulder discovered on Qonochontogue Beach in Southwestern Rhode Island is described by Kemp[9] as a coarse granitite, with nodules from two to three inches in diameter scattered through it. These consist of a center of coarse plagioclase with a little quartz, surrounded by a concentric zone of biotite and magnetite, and a peripheral one of radiating plagioclase, whose laths end sharply against the granite matrix. The author explains the nodules as centers of crystallization.

The rocks that have for the past few years been called muscovadite by the Minnesota Geological Survey have recently been examined by Grant,[10] who finds among them several distinct rock types. Some of muscovadites are fine grained aggregates of pyroxene, quartz and feldspar, containing in their midst large flakes of biotite. Others are composed of quartz and biotite, etc. These are considered as contact rocks. A second class of the muscovadite comprises granulitic gabbros and norites.

The siliceous oolite of State College, Pa., is composed of radial spherules of fibrous chalcedony forming bands around fragments and rounded grains of quartz. Between the spherules are bundles of chalcedony fibres placed normal to the surface of the spherules nearest them, and intermingled with these are granular chalcedony and quartz. An oolite from the Tertiary beds of New Jersey is an aggregate of sphero-crystals of chalcedony, usually without nuclei. Occasionally a cone of fine grained quartz is to be seen, but this is rare. The matrix between the spherules is partly chalcedony and partly quartz.[11]

Duparc and Mrazec[12] refer very briefly to the mineralogical composition of an occurrence of Serpentine at Geisspfad in the Swiss Alps. The rock now contains hornblende, chromiferous diopside, diallage and some secondary substances in addition to serpentine. The rock was probably originally a Lherzolite.

[6]Amer. Naturalist, 1893, p. 274.
[7]Ib. 1893, p. 563.
[8]Amer. Jour. Sci , XLVII, 1894, p. 333.
[9]Trans. N. Y. Acad. Sci., XIII, 1894, p. 140.
[10]21st Ann. Rep. Minn. Survey, p. 147.
[11]E. O. Hovey: Bull. Geol. Soc. Amer., Vol. 5, p. 627.
[12]Bull. Soc. Franc d. Min., XVI, p. 210.

Phillips[13] has analyzed specimens of Pele's hair (I) and of lava stalagmites (II) from the caves of Kilauea, Hawaii, with these results:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	P_2O_5	CaO	MgO	Na_2O	K_2O	Total
50.76	14.75	2.89	9.85	.41	.26	11.05	6.54	2.70	.88	= 100.09
51.77	15.66	8.46	6.54	.82		9.56	4.95	2.17	.96	= 100.89

Lacroix[14] finds specimens of nepheline basalt from Saint Sandoux, Puy-de-Dom, France, in an old collection preserved in the College of France.

Some of the trap dykes of the Lake Champlain region are camptonites. Others consist of monchiquite, fourchite or bostonite. All are described by Kemp and Marsters[15] in a recent Bulletin of the Survey

[13]Amer. Jour. Sci., XLVII, p. 473.
[14]Bull. Soc. Franc d. Min., XVII, p. 43.
[15]Bull. U. S. Geol. Surv., No. 107.

BOTANY.[1]

Notes on a Few Shrubs of Northern Nebraska.—Of 50 shrubs that grow in the northern tier of counties west of Antelope County, some few have interested the writer and may prove of general interest. The observations extend over a period of six years. They are likely to be continued with equal profit in the years to come. The order followed is that of Professor Bessey's "Native Trees and Shrubs of Nebraska."

The only shrub representing the Coniferae is *Juniperus communis* L. I have seen it only in Hat Creek Basin, Sioux County. There it grows in prostrate ascending form, exactly like the juniper of Connecticut, in dry pastures. I have no specimen of the latter, but suppose it to be var. *alpina*.

Corylus americana Walt. is chiefly remarkable for its absence in this region. I have found it only in Cherry County, ten miles east of Valentine and 20 miles southwest on the Niobrara and its tributaries. It is flourishing and abundant where it occurs. Its lack of distribution may be partly accounted for by the late frosts of this high altitude (2600 ft.), which, as this year, destroy the flowers.

Salix tristis Ait. is very common over the sand-hill portion of Cherry County, also in Brown and Holt Counties. When it was sent to Mr. M. S. Bebb from Long Pine, Brown County, he stated that that was its western limit, so far as he knew. It is probable that Cherry County furnishes the limit sixty miles further west. Gray's Manual gives the height "1–1½ ft. high." It grows 5 feet high at Long Pine, in the brush.

Salix cordata is represented by var. *angustata* Anders., though the State claims var. *vestita* Anders. in the other portions. Mr. Bebb (Coulter's Man.) says: "It is altogether incredible, however, that any form of *S. cordata* ever attains tree-like size." I have a specimen at Ewing, Holt County, about twenty feet high and eight inches in diameter—a pretty sizable shrub! I shall measure it and take specimens this season. I will state, however, that it retains its shrubby character by branching ten or fifteen times just above this diameter, some of the branches being five or six inches through.

[1]Edited by Prof. C. E. Bessey, University of Nebraska, Lincoln, Nebraska,

Rhus toxicodendron L. As an instance of adaptability to environment, this species is noteworthy. It is very common on the sandy prairie of this region, perfectly upright, seldom over one foot high, with no tendency to creep, fruiting freely. Even in the brush you will seldom see it as a climber. It deserves more attention than most collectors would care to give it.

The wild crab is represented in these counties by *Pyrus ioensis* (Wood) Bailey. It has been commonly called, heretofore, *P. coronaria* L., but is much too white-wooly. It forms large patches covering several acres in extent, and, when not browsed by cattle, produces useful fruit. Its western range, so far, is northern Brown County.

Crataegus coccinea L. also represents the family with its beautiful scarlet clusters of edible fruit. While stray trees have been found in Cherry County, probably coming south from Rosebud Agency, where it is said to be common, I have not found it common west of Holt County.

Amorpha microphylla Pursh. is a new shrub in Nebraska. I found it last year (1893) on the gumbo hills of Holt and Boyd Counties, very common, but quite confined to that soil. It was reported also from another section of the State.

Up to the present time, no species of *Oenothera* has been reported as shrubby so far as my reading extends. I have seen indications in past years that caused me to suspect *Oenothera serrulata* Nutt of having the character, to some extent. This year, I have abundant confirmaion. Here at Valentine. after a dry, hard winter that has killed whole timber claims of forest trees by freezing dry, a plant of this species has bloomed vigorously on shoots six inches long, starting from last year's stock five to six inches above the ground. The situation was fully exposed to all the rigors of the season. I have found several other plants sprouting vigorously two and three inches above ground. It shows about the same degree of hardiness as half the plants of *Amorpha canescens* Nutt., and quite as much as *Gutierrezia euthamiae* Torr. & Gray in this climate, both of which have long been classed as shrubs.

Valentine, Neb. —J. M. BATES.

Botany at Brooklyn.—The recent scientific meetings in Brooklyn brought out a good number of botanists, whose papers and discussions touched upon nearly all parts of the subject of Botany, from Bacteriology to Paleobotany. That all were of a high order of merit could not be truthfully affirmed, but that all were creditable, and some of unusual interest is true. The botanists of the country have no rea-

son for feeling ashamed of their work as represented in these meetings.

In the Society for the Promotion of Agricultural Science nearly every paper dealt with some question more or less botanical. Here of course, the treatment was economic rather than strictly scientific, and yet in every case there was much of interest to the botanist. Thus there were papers on "The Vitality of the Seeds of Red Clover" (*Beal*); "The Russian Thistle in Nebraska" (*Bessey*); "A possible Relation between Blights and Exceptional Weather" (*Halsted*); "The Growth of Lettuce as affected by Physical Properties of the Soil" (*Galloway*); etc., etc.

The Botanical Club of the Association held several interesting sessions, and took active part in a delightful excursion by boat to Cold Spring Harbor on the north shore of Long Island. Among the notes presented before the club were the following: "The Prothallium of *Marsilia vestita*" (*Bessey*); "Notes on Oat-Smut" (*Jones*); "The use of Formalin as a Preservative Agent" (*Galloway*); "Sporangial trichomes on Ferns" (*Durand*); "The Significance of Stipules from the standpoint of Paleobotany" (*Hollick*); "A Plea for the better Pronunciation of Botanical Names" (*Bessey*); "A Species of *Olpidium* parasitic on *Spirogyra*" (*Durand*); "A method of making pure cultures of Fungi" (*Smith*); etc., etc.

A Committee on the pronunciation of Botanical Names was appointed consisting of Charles E. Bessey, N. L. Britton and E. L. Greene. The officers for the next year are Douglas H. Campbell, of Palo Alto, California, and Frederick C. Newcomb, of Ann Arbor, Michigan.

Twenty-six papers were read before Section G, beginning with the opening address by Vice-President Underwood, upon "The Evolution of the Hepaticæ." In this the speaker traced in a masterly way the evolution of the several groups of the liverworts, pointing out their mutual relationships, as well as their affinities with higher and lower plants.

The other papers were as follows:

B. T. Galloway, "The Growth of Radishes as affected by the Size and Weight of the Seed"; Katherine E. Golden, "The Movement of Gases in Rhizomes"; A. D. Hopkins, "Some Interesting Conditions in Wood resulting from the attacks of Insects and Woodpeckers"; W. J. Beal, "The Sugar Maples of Central Michigan"; John M. Coulter, "Some Affinities among Cactaceæ"; Charles E. Bessey, "Simplification and Degeneration"; Frederick C. Newcomb, "Regu-

latory Growth of Mechanical Tissue"; Charles E. Bessey, "Further Studies of the Relationship and Arrangement of the Flowering Plants"; Erwin F. Smith, "The Watermelon Disease of the South"; L. H. Bailey, "The Relation of Age of Type to Variability"; L. H. Bailey, "The Struggle for Existence under Cultivation"; "George F. Atkinson, "Relation between the Functions of the Vegetative and Reproductive Leaves of *Onoclea*"; H. H. Rusby, "*Lophopappus*, a new genus of Mutisiaceous Compositæ and *Fluckigeria*, a new genus of *Gesneriaceæ*"; George F. Atkinson, "On the Swarmspores of *Pythium* and *Ceratiomyxa*"; Elizabeth G. Britton, "A Revision of the genus *Scouleria*"; B. G. Wilder, "Evidence as to the former existence of large trees on Nantucket Island"; N. L. Britton, "Notes on Primary Foliage and the Leaf-scars in *Pinus rigida*"; Byron D. Halsted, "Notes upon *Chalara paradoxa*"; Elizabeth G. Britton, "A Hybrid among the Mosses"; Byron D. Halsted, "Notes upon a Root-rot of Beets"; N. L. Britton, "On *Torreya* as a Generic Name"; Elizabeth G. Britton, "Some Notes on the genus *Encalypta*"; Jed. Hotchkiss, "The Growth of Forest-trees illustrated from marked corners 107 years old"; Mrs. F. W. Patterson, "Species of *Taphrina* parasitic upon Populus"; Albert Mann, "Products of Metamorphosis and Monstrosities" (by title only).

Reports of progress were made by several of the Committees appointed last year, and they were continued for further work.

The Committee of the charter members of the Botanical Society of America held several meetings persuant to a call of the Chairman, Dr. Trelease, and perfected the organization of the Society. Much time was spent in discussing the details of the organization, and in perfecting plans for work. The officers for the ensuing year are as follows: President, William Trelease, St. Louis; Vice-President, N. L. Britton, New York; Secretary, Charles R. Barnes, Madison, Wis.; Treasurer, John D. Smith, Baltimore.

Provision was made for a meeting sometime during the summer of 1895, the time and place to be announced later by the Executive Committee.

Charles E. Bessey.

ZOOLOGY.

On the Vertical Distribution of Pelagic Crustacea in Green Lake, Wisconsin.—Green Lake is the deepest body of water in the State of Wisconsin, having a maximum depth of about 60 meters. Because of its great depth it has not only the litoral and pelagic faunæ of the shallower bodies of water, but also the true abyssal fauna which is characteristic of the deeper lakes. In fact, the crustacean fauna of Green Lake is almost identical with that of the great lakes.

In the deeper waters of Green Lake are found fifteen species of crustacea. Of these, twelve may be fairly considered as belonging peculiarly to the deep water fauna. Most of these can be captured in very large numbers at night by means of the skimming net. During the day, very few are found at the surface, some few never come to the surface, and are only obtained by dredging in the deep water.

Of course, an open dredge, dropped from the surface to the bottom and then hauled up, will collect from all depths. After a little experience, the collector has no difficulty in distinguishing between pelagic and abyssal species, and can even draw inferences, with a reasonable degree of accuracy, in regard to the general vertical distribution of species. So far as I know, however, very little exact work has been done to determine the vertical limits of the various species. By means of dredges which could be closed at any required depth, it has been found that in the deep sea there is a surface fauna and a deepwater fauna, but that the immediate intermediate region is barren of animal life. According to Agassiz, the surface fauna extends to the depth of 200 fathoms, and the bottom fauna is limited to about 60 fathoms.

Is there a similar condition in the waters of our lakes? With a view to answering this question, I made some preliminary collections in the summer of 1893.

I used, for the collections, a vertical dredge, so constructed that it could be closed at any desired depth. The collections upon which this paper is based were made in the latter part of August, at all hours between five o'clock in the morning and nine o'clock at night. Each series included collections for every five meters in depth. Of course, until a much larger number of collections is made, and at different seasons of the year, no final conclusions can be drawn. But the results

thus far are interesting, and I think later collections are not likely to modify, to any great extent, the conclusions I have formed.

The results were a little disappointing to me at first, I must confess. I had made up my mind that I should find the three regions characteristic of the deep sea—the pelagic, intermediate and abyssal. It was rather discouraging, then, when I found material in my dredge from all depths. Not only that, but when I began to examine the collections under the microscope, I found certain species, which I had considered peculiar to the surface—like *Diaptomus minutus*—occurring all the way from the surface to the mud of the bottom. The barren intermediate zone, then, does not exist in Green Lake. It is true, however, that the numbers of individuals are less at intermediate depths than near the surface or near the bottom, and that some species are vastly more numerous in the upper zone, while others are almost entirely confined to the lower.

I counted the number of individuals in each haul, and after reducing the numbers to percentages, tabulated the results.

I will give briefly the conclusions I reached in regard to those species which are found most commonly.

The species which is found in the greatest numbers is *Diaptomus minutus.* In one haul this was associated with *D. sicilis* (a somewhat rare form in Green Lake), and in my computation I did not separate the two, as their habits are identical. On the average, 46 per cent of this species is within five meters of the surface, and 59.4 per cent within ten meters. Within ten meters of the bottom are only 7.37 per cent. It is evident that more than one-half of the individuals of these species are found within ten meters of the surface, and that from that point to the bottom, the numbers steadily decrease.

Daphnella is more exclusively pelagic—79 per cent being found within ten meters of the surface, and only 5.6 per cent at the bottom.

Epischura is still more distinctly pelagic—81 per cent being in the first ten meters, and 3.3 per cent in the last ten.

Leptodora, Bosmina and *Cyclops fluviatilis* are also found much more abundantly near the surface. *Leptodora* rarely goes below fifteen meters.

Daphnia kahlbergiensis seems somewhat erratic in its distribution. On the average, nearly 43 per cent are found within the first ten meters, but nearly 25 per cent are found in the last ten. Generally speaking, they appear more numerous near the surface and the bottom, but less so at intermediate depths. But they may occur at all depths, and sometimes quite numerously in the intermediate region.

Limnocalanus macrurus rarely, if ever, comes to the surface, and is found most abundantly within 20 meters of the bottom. Nordqvist states that he found *L. macrurus* in Finland, in June, most abundant at twelve meters below the surface, where the total depth was 25 to 26 meters.

Pontoporeia and *Mysis* live at the bottom, and belong to the true abyssal fauna.

In regard to the diurnal migrations of the pelagic species, I found it difficult to fix any exact limits. As has been before stated, they come to the surface at night. In the daytime, few of them go below ten meters. *Daphnia kahlbergiensis,* however, seems to be an exception, for, apparently, its migrations are limited only by the depth of the lake, and sometimes from 40 to 80 per cent are in the last ten meters.

As a result of these collections, I was led to doubt the value of "Plankton" determinations, at least so far as crustacea are concerned. All such determinations must start with the assumption that the life of the deeper waters is distributed uniformly. If this were true, successive hauls in the same depth of water would contain approximately the same number of individuals. This was far from the case in my collections. The position in the successive collections varied only as the boat drifted very slowly; yet the number of *Diaptomi* varied from 291 to 2,966; *Daphnella* from 0 to 122; *Daphnia kahlbergiensis* from 6 to 103, and *Epischura* from 7 to 105. It seems probable that they are present in swarms, and that the positions of the swarms are continually changing.

Zacharias, in his last report from the biological Station at Plön, has reached the same conclusions, not only in regard to the crustacea, but also the other pelagic organisms. "Plankton" determinations, in order to have much value, must be almost infinite in number.

Beginning with the fall of 1894, systematic work of a more detailed character will be carried on at Green Lake, as the Trustees of Ripon College have made an appropriation for the purpose.

—C. Dwight Marsh, Ripon College, Wisconsin.

Rotatoria of the Great Lakes.—The Michigan Fish Commission have issued, as Bulletin No. 3, a list of the Rotatoria found in Lake St. Clair and some of the inland lakes of Michigan, prepared by Mr. H. S. Jennings. Of the 122 rotifers named in the list, 6 are here described and figured for the first time. Strongly swimming forms, commonly found in the open water, are designated pelagic; those found among the vegetation of the shores and bottom, littoral. Of the former,

20 were observed in Lake St. Clair. In the case of the inland lakes, collections were made from the shore only. The most abundant pelagic species are *Polyarthra platyptera* Ehrbg., *Anuraea cochlearis* Gosse, and *Asplanchna priodonta* Gosse, which agree, in this respect, with the condition found in European lakes.

The Internal Anatomy and Relationship of Pauropus.—According to Peter Schmidt, whose preliminary paper appeared in the *Zoologischer Anzeiger*,[1] the internal anatomy of *Pauropus* allies it most closely with *Polyxenus* among the Diplopoda. The absence of trachea, of malpighian tubes and of a circulatory system, together with the presence of a rather complicated genital apparatus in the male, seem to show that it is very degenerate. That it belongs along with the Diplopoda—a fact that has been questioned—the presence of the ovary below the intestine, of the genital openings in the third body segment behind the second pair of legs, and of only two pairs of oval appendages, abundantly testify. The biramose antennæ may possibly be explained by a comparison with the sense papillæ at the end of the terminal joint of the Diplopod antenna, the more readily, too, since, according to Schmidt, the distal portions of the rami, the geisseln of Latzel appear to be finely ringed and not segmented.

Several peculiarities are interesting. The mid-gut is without a *muscularis* and its epithelial cells are filled with rhomboid crystals with double refractive powers. The supra- and sub-œsophageal and the first body ganglia are fused into one mass which is pierced by a very short fore-gut. The small processes on the first segment represent rudimentary legs and possibly function in respiration like the abdominal sacs of Thysanura, Symphyla and certain Diplopods. The sense organ of the antennæ, the *globulus* of Latzel, consists of an outer and inner capsule with the intervening space filled with a fluid. The whole is surrounded by ten or twelve bristles while the nerve passes into the inner capsule and expands into a nail-like head. (Fig: 1.)

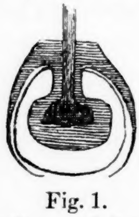


Fig. 1.

The female genital apparatus consists of an unpaired ovary lying, beneath the intestine, an unpaired receptaculum seminis and an oviduct opening to the exterior by an unpaired opening to the one side of the median line in the third segment. In the male there is an unpaired testis above the intestine, a complicated pair of ducts, a pair of seminal

[1] Zur Kenntniss des inneren Baues des Pauropus huxleyi Lubb. Zool. Anz., XVII, 189.

glands, and a pair of genital openings. Near the middle the testis communicates with the two small vasa deferentia that open into two

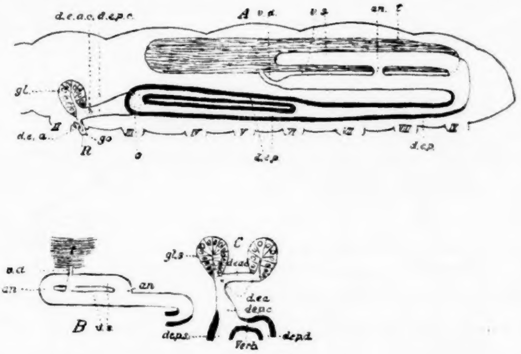


Fig. 2.

Diagrammatic representation of the male genital organs of *Pauropus huxleyi* Lubb. A. From the left side, II–IX the coxæ of the II–IX pairs of legs; t, testis; v.d, *vas deferens;* v.s., *vesiculæ seminales;* an, anastomosis; d.e.p., *Ductus ejaculatorius posterior;* o, opening between the d.e.p.; d.e.p.c., *Duct. ejac. post. communis;* d.e.a.c., *Duct. ejac. anterior communis;* gl., *glandula accessoria;* d.e.a., *Duct. ejac. anterior;* go, genital opening; R, penis.

B. From the right, somewhat shortened.

C. The anterior part from above.

large tubes which are bent upon themselves. These open posteriorly into two ducts that run forward beneath the intestine. The anterior half of each of them is double. In the fourth segment they unite into a short tube on the side of the body. This communicates with a transverse tube into which the seminal vesicles open, and which opens to the exterior by two openings.

The spermatozoa are pod-like. —F. C. Kenyon.

Thysanura from the Cave of Central France.—M. R. Moniez describes three new species of Thysanoures from the grotto of Dargilan in the Department of Lozére, France. The first, *Campodea dargilani*, appears to be the third of a series of forms adapted progressively for a life in darkness. That is, the characters of *C. staphylinus*, the type of the genus living in open air, are more accentuated in *C. coopei*, a cave form, and are carried to an extreme in *C. dargilani*. The second, *Sira cavernarum*, is white, covered with transparent scales, and is entirely blind. The third, *Lipura cirrigera*, is characterized by

tufts of 6 or 7 cirrhi at the base of the second joint of the attennæ. These cirrhi are spaced at their insertion and recurved. These organs are present in the other Lipurae, but in so rudimentary a state that they have heretofore escaped observation. (Revue Biol. de Nord., Dec., 1893).

Result of a Comparison of Antipodal Faunas.—Prof. Gill's paper on a comparison of the piscine fauna of the British island with that of the New Zealand waters contains some important deductions. An analysis of a tabulated list of the families of these two regions shows that twenty-five families are represented in the New Zealand seas and not in the British; of these eleven are peculiar to the Southern Hemisphere; four are represented in the Northern Pacific, but not in the North Atlantic; and ten, although not represented in the British seas, have quite a general distribution.

Of the fresh-water species, those characteristic of the Northern Hemisphere are, with the exception of the Argentinidae, entirely unrepresented in the Southern, while the Antipodal types are wanting in the Northern zones.

According to Professor Hutton, the New Zealand Fishes belong to no less than six distinct geographical realms: Notalian, Antarctalian, Pelagalian, Bassalian, Tropicalian and Ornithogæan. A consideration of these various elements and comparison of them with those of other regions leads Dr. Gill to the following conclusions:

"The main marine fauna of New Zealand is derived from representatives of the general stock which has become developed in the great Notalian realm. The number of species apparently peculiar to the province, and, therefore, modified from other or earlier representatives, indicates a long period of isolation in accordance with its distance from the nearest continents and the depth of the intervening ocean. The percentage of such peculiar species seems to entitle it to rank as a distinct region (or subregion) rather than as an integral portion of the Notalian region composed of the isothermal portions of Australia and Tasmania, as has been generally done. A more extended study and actual comparison of the species of the two regions may, however, compel a reconsideration of this view."

"The fresh-water fishes must have been derived from the same common source as those of the isothermal portions of Australia (of course, including Tasmania) and South America. There may not have been a continuity of land at any one time between South America, Australia and New Zealand, but, at more remote period in the past, it is, at

least, possible that there was a region in which the Galaxiids and Haplochitonids were developed, and subsequently representatives of those families might have found their way into the regions where they now abound."

In the discussion of the possibilities of the origin of the present types of the fresh-water fishes of New Zealand, it appears that Dr. Gill is of the opinion that "community in type must be the expression of community of origin, and the presence of fishes of long-established fresh-water types must imply continuity or at least contiguity of the lands in the midst of which they occur at some time or other." He then adds: "We may be permitted to postulate (fishes being congeneric in New Zealand, Australia and South America), that there existed some terrestrial passageway between the several regions at a time as late as the close of the Mesozoic period. The evidence of such a connection afforded by congeneric fishes is fortified by analogous representatives among insects, mollusks, and even amphibians. The separation of the several areas must, however, have occurred little later than the early Tertiary, inasmuch as the salt water fishes of corresponding isotherms found along the coasts of the now widely separated lands are to such a large extent specifically different. In general, change seems to take place more rapidly among marine animals than fresh-water representatives of the same class." (Fifth Mém., Vol. VI, Natl. Acad. Sciences.)

The Carotid, Thymus, and Thyroid Glands form the subject of a rather lengthy paper by A. Prenant.[2] He had a good series of embryos, and studied carefully the histological changes during development. According to him the carotid gland originates from the third entodermal branchial pouch, and at first becomes closely connected with the primitive carotid artery, but later loses this connection and becomes united with the head of the thymus. In regard to the lymphoid transformation of the thymus, he says that in embryos, from 25 and 85 mm. in length, there appear small nuclear elements among the primitive epithelial cells, which stain deeply and are comparable to lymphocytes. The thymus in embryos of 85 mm. and upwards begins to differentiate itself into an outer cortical portion and an inner medulary portion. The latter is clearer, looser in texture and poorer in lympathic elements than the cortical portions. This further becomes differentiated into a peripheral and an inner portion. The former stains less, is richer in karyokinetic figures than the latter. It

[2]Contribution à l'etude de développement organique et histologique des Thymus de la glande thyroid, et de la glande carotidienne. A. Prenant, La Cellule, X.

is doubtless a germ of proliferation. Nothing surrounding the organ authorizes the supposition that this is a muscular connective tissue which produces the lymphocytes that fill the organ. It is probable that epithelial cells after multiplying actively by mitosis, give rise to the lymphocytes by simple division (stenose). For large nuclei with small buds frequently occur and small nuclear bodies may be seen by the side of large nuclei and within the same. This mode of division is more common in the earlier stages. In older embryos the lymphocytes are formed karyokinetically. The epithelial cells that probably persist even in the completely developed organ he compares with the cells forming the matrix of the testis and the coveys of lymphocytes arising from them with the seminal elements.

The lateral portions of the thyroid develop from the fourth entodermal branchial pouch, which is forked. From the angle of this there grows up an organ that in structure and appearance is comparable with the carotid gland. This he calls the *glande thyroidienne.* It finally comes to lie outside of the vascular-connective hilum of the thyroid. During development an anfractuous cavity appears in the thyroid and is prolonged in every direction by deep diverticula. At first its walls are stratified and then simple. The superficial cells disappear after a transformation comparable to that which occurs in the internal assizes of the epithelium of the æsophagus. The wall produces around itself a cellular reticulate structure of dense aspect, which later disappears. Whether the lateral gland gives rise to buds that become confusingly anastomosed and eventually transformed into thyroid vesicles, or whether the lobes of the median gland solder themselves to the tissue of the lateral gland, it is impossible to say.

There is very little of a comparative nature in the paper beyond an attempt to introduce a formula to represent the number and position of the glands in invertebrata. This is not nearly as readily understood as a simple diagramatic figure; moreover, it is entirely unnecessary.

Of possible interest in connection with the work of Prenant is a short paper by J. Beard on the Development and Probable Function of the Thymus.[3] In Raja he declares that the epithelial nature and appearance of the cells composing the gland is lost very soon after their formation. Their nuclei stain intensely, and the cell-body, i. e., the protoplasm, is very scant from the start. It is clear that there is no inwandering of lymph cells, but that these elements are the direct offspring of the epithelium of the gill cleft.

[3]Anat. Anz., IX, p. 476.

As to the function of the gland, bearing in mind the observations of Stöhr and Killian on the tonsils, he concludes that the thymus exists in fishes for the protection of the gills from bacteria, etc., by the formation of leucocytes. With the disappearance of the gills of fishes and perrennibranchiate amphibians, the gland undergoes a restriction in the area of its formation and its functions are transformed to other organs. In the higher vertebrates this protective function is transferred to the tonsils at the opening of the respiratory passage.

—F. C. Kenyon.

ENTOMOLOGY.[1]

On the larvæ and pupæ of Hololepta and Pyrochroa.—Aside from those of direct economic importance, the larvæ of North American Coleoptera have received too little attention from entomologists, and many of our common beetles are quite unknown in their early stages, while others have received passing notice in text-books or agricultural reports, with here and there a figure, and sometimes a few words of description, more or less vague. Many of the injurious ones have been, however, investigated in the most thorough manner by our best students of insect life.

The two species treated of in the present paper have not before been given space in our literature beyond, in one case, a short note. It has, therefore, been thought fit to furnish detailed descriptions and figures for the use of those who may wish to indentify specimens in their possession.

HOLOLEPTA FOSSULARIS Say. Plate XXVI, figs. 1, a, b, c, d.

Color of larva nearly white, head chestnut, prothorax with a triangular space, occupying most of the upper surface, a little lighter than the head. Back with a dark line for the greater portion of the length where the viscera show through.

Form elongate, somewhat flattened; length 17.5 mm.

Head castaneous, quadrate, broader than long; above strongly flattened, with four impressed lines on the front and an impressed space near the base of each antenna, from which a line of punctures runs to the base. Anterior margin produced, truncate in front, and with a lobe over each mandible. Beneath, less flattened, with a broad, deep impressed space on the gular region, extending in the form of a narrow groove to the base.

Antennæ arising from the sides of the head, immediately behind the base of the mandibles, four-jointed, the first joint very short, sunken, the second long, the third shorter, subtriangular, with three papillæ at end, fourth joint again shorter, elongate oval. There are, apparently, no bristles, except two short and inconspicuous ones at the tip of the last joint.

Eyes are, apparently, altogether wanting.

[1] Edited by Clarence M. Weed, New Hampshire College, Durham, N. H.

Mandibles stout, rather long, curved, with a strong, rounded tooth before the middle.

Maxillæ composed of a long, stout basal piece, heavily bristled, especially on the inside, a shorter second joint, which bears a one-jointed appendix, tipped by a bristle, on the outside; third, fourth and fifth joints subequal, the last two, however, a trifle longer and more slender.

Mentum borne on a tuberculiform base, elongate, wider near the tip, palpi two-jointed terminal joint longer.

Prothorax corneous, transverse, sides and base somewhat rounded, apex nearly truncate, median line distinct, rather deep, a deeper impression each side external to which is a vague foveate impression. Beneath with two deeply impressed lines strongly convergent anteriorly, posterior to which are two foveæ.

Meso- and metathorax much shorter than the prothorax, membranous with a long, crescentic, horny scute at middle, both above and below, and smaller ones at sides. Each of these segments bears a lateral bristle.

Abdomen of nine segments, which are protuberant near the middle of the sides and transversely wrinkled, armed with two lateral and one ventro-lateral bristle on each side. Each segment except the last is granulato-spinose on the scutes of the under surface; the last bears two bi-articulate appendages, each armed with five bristles, as shown in the figure. The anus is inferior.

Spiracles in nine pairs, the first situated beneath the anterior mesothoracic angles, the others in segments 1 to 8 of the abdomen, near the anterior margins and somewhat ventro-laterally.

Legs small, weak, slender. The coxæ are rounded, imperfectly chitinized, the trochanter distinctly marked, femur somewhat creased on the edges, tibiæ shorter, slightly bristled, claw single with two short bristles at about the middle of the length.

The pupa is white, 10 mm. in length and of the same general shape as the beetle, but with a more pointed abdomen; the meso-metasternal area is coarsely punctured.

Nearly full-grown larvæ of this species were found under the bark of an old cottonwood log near the end of March, between the thin layers next to the wood. In captivity they fed upon the pupæ of Diptera taken in the same situation. After several days the largest one constructed a case of small pieces of bark; the dimensions were 14 by 7 mm., the outside rough, but the inside perfectly smooth. In this case the change to a pupa took place after a rest of above a week.

PYROCHROA FLABELATA Fabr. Plate XXVI, figs. 2, a, b, c, d, e, f.

Color of full-grown larva clear, light yellow, the head, especially the mouth parts, and the terminal processes castaneous.

Form elongate, much depressed, sides sub-parallel, slightly broader behind, segments with dorso- and ventro-lateral bristles. Terminal segment corneous with two stout processes directed upward and backward. Length 34.5 mm.

Head corneous, free, the sides strongly rounded, front produced at middle, labrum distinct, tip sinuate more prominent at middle, anterior margin strongly bristled, suture very slightly sinuate. Top of head with a depressed space surrounding a large tubercle, anteriorly with transverse striations and two tolerably distinct longitudinal lines.

Eyes consist of four ocelli on each side of the head, just posterior to the antennæ. The three anterior ones in each group are arranged in a slightly oblique curved line, back of the middle of which the fourth is placed.

Antennæ lateral, situated behind the base of the mandibles, four-jointed, the first joint stout, short, the second long, third and fourth subequal, together somewhat longer than the second. The fourth joint is much more slender than the third, and all are strongly bristled.

Mandibles extremely stout and heavy, deep, the tip emarginate, internally strongly toothed, as shown by the drawing.

Maxillæ large, strong corneous; the lobe is sinuate on the inner margin and armed with bristles, those near the end arrayed in rows, the inner apical ones recurved. The palpi are stout, the second and third joints about equal and separately longer than the first; all are bristly.

Mentum of the form shown in fig. 2 f. The shaded portion is thicker and more perfectly chitinized than the remainder, and has every appearance of being divided by sutures from the underlying and superimposed pieces.

Prothorax about equal in width to the head, the sides nearly straight, except at the angles, where they are abruptly directed inwards. Median line distinct with a fovea each side anterior to the middle and crossed in front of these by a fine transverse line. Beneath with two strongly impressed lines which, originating between the coxæ, diverge strongly in front and attain the margin near the anterior angles, the triangular space thus enclosed being also bistriate at middle.

Mesothorax broadest near the base, more convex than the prothorax, with distinct median line, and, on each side of this, a vague double fovea,

slightly behind the middle. Anteriorly there is a fine transverse line crossing the median one at right angles. Beneath is a smooth subquadrate space, usually bounded at sides and behind (except for a short distance at middle) by broad, deeply impressed lines.

Metathorax similar, but the lines beneath effect a junction at the middle.

Abdomen with the first seven segments quite similar in form, subangulate at the sides, median dorsal and anterior transverse lines distinct, the former more so. Beneath is a very well marked submarginal plica. The eighth segment is larger, longer, more perfectly chitinized, sides slightly rounded. Median dorsal line very distinct, with a less distinct oblique one on each side. Beneath there is an impressed median line which has posteriorly a slightly elevated carina on each side; external to this is a sinuous broader line each side, and outside of this again a very deep impression which extends from a point distant about one-fifth from the basal lateral margin to the posterior angle of the segment. The anal segment is small, carinate, more distinctly at base, visible only from beneath, being overlaid by a corneous plate bearing two spinose and granulate processes. Viewed from above the space between these processes is somewhat semicircular in outline, and the two *cul-de-sacs* between them are distinctly visible. From beneath the processes look almost straight and the *cul-de-sacs* do not appear. The accompanying figure will give a much better idea of this complicated structure than a description can convey.

Spiracles in nine pairs, the first situated in the mesothorax under the anterior angles, the rest abdominal. The pair on the first abdominal segment is dorso-lateral, the next lateral, and the remainder (in segments 3 to 8) are ventro-lateral; all except the last pair, which are behind the middle, are placed nearer the anterior than the posterior margin of the segment.

Legs stout, coxæ not very prominent, femora strong, broader at tip and compressed within, tibial pieces subcylindrical, claws single, long, curved, with an indistinct blunt tooth and a bristle near the base. The suture between the femur and trochanter is well marked, and these as well as the tibiæ are rather sparsely bristled.

Larvæ of the above mentioned species were taken at Iowa City on the 13th of April from beneath the bark of a rotting elm log. On the 7th of May one of them changed to an elongate white pupa, 16 mm. in length, which had the power of moving very rapidly about on its back, tail foremost. It was very sensitive, a slight touch on any of

the bristles sufficing to set it in motion. The beetle appeared on May 16th.

In a short note on page 76 of the third volume of Psyche, Mr. H. L. Moody has given us a means of distinguishing the larvæ of four of the species of the family Pyrochroidæ that he has raised. The larva of *Schizotus cervicalis* he says is of a smoky tint, while the remaining three (mentioned hereafter) are yellow; of these, *Dendroides canadensis* has long, slender, curved processes nearly one-third longer than the basal portion, and the *cul-de-sacs* not visible from above; *D. concolor* has stouter, nearly straight processes hardly longer than the basal portion, and the tips are obliquely cut off on the inner side, while the *cul-de-sacs* are just visible (by the projecting lower margin) from above. In *Pyrochroa flabellata* the processes are nearly straight on the inner edge when viewed from below, and short, strongly dentate; the *cul-de-sacs* are very large, plainly visible from above. I notice that the length of the processes is subject to some little variation, but no doubt these characters will hold good in general.

Explanation of Plate.

Fig. 1. *Hololepta fossularis* Say, larva; *a*, pupa; *b*, mouth and antenna from below; *c*, anterior leg; *d*, caudal appendix.

Fig. 2. *Pyrochroa flabellata* Fabr., larva; *a*, pupa; *b*, antenna; *c*, mandible; *d*, terminal portion of abdomen from below; *e*, maxilla; *f*, mentum.

H. F. Wickham, Iowa City, Iowa.

ARCHEOLOGY AND ETHNOLOGY.[1]

Gailenreuth Cave in 1894.—Dr. Zittel says (Beiträge zur Anthropologie und Urgeschichte Baierns ii, p. 226) that the remarkable discoveries in the English and French caves about 1875, caused the comparatively recent exploration, notably by Dr. Fraas (about 1877), of caverns in the limestone valleys of the upper tributaries of the Main (in the Franconian Switzerland, Bavaria) and along the northern confluents of the Danube (in Würtemberg). But, as he explains, J. F. Esper (Ausführliche Nachricht von neuentdeckten Zoolithen, 1774), had scientifically examined several of the Wiesent Valley caves (in Franconia) more than a hundred years before, and, as far as is known, had anticipated all investigators—even the Rev. McEnery, the long-neglected explorer of Kent's Hole—in the discovery of human remains associated with the bones of extinct Plistocene mammals.

The cave map of Bavaria (Beiträge zur Urgesch. Bai. 2, plate 14) is thickly dotted with the red signs for caverns in the mill region north of the right Danube bank between Ulm and Ratisbon, here and there in the Alpine valleys of the Iller, Isar and Saal far to the southward, but thickest of all along the upper Main Valley by the Wiesent, Ailsbach and Püttbach tributaries, about a spot twenty miles to the southwest of Bayreuth. Here it was, in the hill-top cave, one-quarter of a mile from the Castle Gailenreuth (left bank of Wiesent, two miles above Muggendorf), that Esper's most important work was done. The entombed bones of legendary Dragons and Unicorns, the extraordinary teeth exhumed during the Middle Ages to be ground into medical nostrums, had not yet been rearranged into the now well-known shapes of Mammoth, Cave Bear, Hyena and Rhinoceros. Human prehistoric work in stone was unrecognized, and the existence of River Drift and Cave Men was unsuspected, when at Gailenreuth, on finding a human jaw with three teeth and a shoulder-blade in a layer of "Antediluvian" bones, Esper made the memorable observation:

"Since they (the human remains) lay under the animal bones with which the Gailenreuth Cave was filled; since they were found in what, in all probability, was their original layer, I infer, not without adequate ground, that these human relics were of like age with the animal remains above them."

This remarkable inference, in 1774, making Gailenreuth classic ground for the cave explorer, was carried no farther by Esper. Nor

[1] This department is edited by H. C. Mercer, University of Pennsylvania.

did it impress Buckland who, though he visited the cave in 1816, and carried a skull afterwards found (now in the Oxford Museum) to England, seems to have regarded with indifference the similar observations of McEnery at Kent's Hole. No further cave exploration was undertaken in the Franconian region until 1878.

The Gailenreuth Cave or "Zoolithenhöhle" enters the top of a gentle hill separated from the brink of the widest gorge (about 290 feet deep) by a level plateau. Cold and wet as I found it, in August, 1894, and accessible from the stream only after a steep climb, with an entrance (now walled up) invisible from the valley, and not at all conspicuous from the plateau above, the remote forest-hidden cavern, like Hartman's Cave in Pennsylvania, had the look rather of an animal den than a possible habitation for primitive savages.

Esper found its two spacious chambers as now level-floored with the entrance and ending in two or more chasms 20 feet deep by 6 to 10 feet in diameter in the rear. His description makes it uncertain whether he dug his trenches at the bottom of the chasms or on the chamber floors, how deep he went, and whether he reached rock bottom. In his search for bones the following points were noted:

(1) *The pottery.*—The whole cave floor (chambers and chasms) was covered with a bed of charcoal, above which rested a layer of potsherds. These he divided into four kinds: (a) rude hand made of red brick clay mixed with coarse sand; (b) of rude, sandy clay, with fragments of quartz; (c) of finely worked potters' clay, smoked dark and glazed outside and in; and (d) of carefully worked, fine red potters' clay.

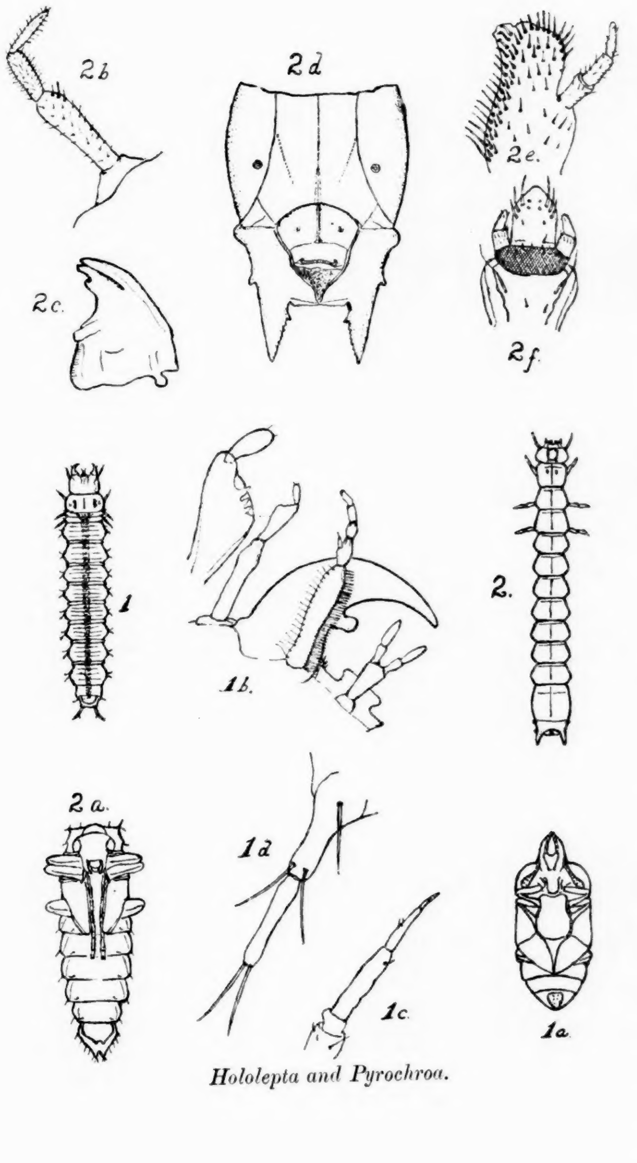
Repeating the notion of cremation of bodies, he supposed that the potsherds were the remains of the urns in which food had been placed near sacred fires built by Huns or Wends to the spirits of their kinsfolk 800 to 1000 years before.

This pottery is still abundant. I scratched out several pieces in the disturbed earth at the bottom of one of the chasms. Esper says that it does not occur at a greater depth than three feet.

(2) *The immense number of animal bones*—The fauna afterward identified, given by Ranke, consisted of Mammoth, Giant Elk, Reindeer, Cave Bear (dominant), Gray Bear, Brown Bear, Cave Lion, Cave Hyena, Woolly Rhinoceros,[2] Wolf, Fox, Beaver, Glutton, Cave Rat and Ground Squirrel. The bones lay in confusion at the bottom of the chasms and in a thick bed under the potsherds on the chamber

[2] Ranke (Beiträge 2, p. 196), quoting Dawkins, does not mention Woolly Rhinoceros, Glutton (*Gulo spelaea*), Beaver, *Arvicola spelaea*, and Squirrel, but I found them labelled from Gailenreuth in the Schloss Museum at Bayreuth.

PLATE XXVI.



Hololepta and Pyrochroa.

floors, and how they got there has remained a puzzle to the present day. I found the gnawed fore-leg bone of *Ursus spelaeus* at the bottom of one of the chasms, but the Carnivora or men could not have brought in the fossils, since none, it seems, have been mentioned as split for the marrow and very few gnawed.

If water washed them in (and this has seemed likely from the pebbles found mixed with them), then we must imagine a valley nearly the size of the Niagara Gorge, as yet uneroded, with the Wiesent somehow sweeping into the cave the bones and not the carcasses of animals that had perished along its shores.

Animals often go into caves to die, but Esper urges they could not have done so in this case, as he found no skeletons entire. He suggests an immense flood driving them to the cave for refuge, where, being drowned, their remains were washed about and broken by surging waters. But, after fairly stating the objections to this and other theories, he gives up the problem in despair.

Esper based his notion of the immense number of animals represented, not on the fragments found, but upon a white, chalky layer of decomposed bones, which he does not describe as continuous, discovered by him in several parts of the cavern. If we give this up as a test of quantity, we have only left for a witness of the often alleged prodigious number of individuals in Gailenreuth, the thickly scattered fragments from 3 to 6 inches long, and in the proportion of about 15 to a half bushel of earth, which I saw on scratching with a hoe, at the bottom of the chasms.

Spite of all the bone hunting done in the cave, there are probably as many of these pieces (which no collector would want) as ever. And if it is fair to guess at the ratio of bones to earth from them, and from the odds and ends set in the growing stalagmite of the walls, the number of entombed animals, though great, was not extravagantly so.

(3) *The human bones.*—The jaw and shoulder blade Esper found at a depth, not exactly stated, of several feet under an extending ledge of rock at a point not since identified. They were bedded in a layer one foot thick of fossils mixed with pebbles, which underlaid the white chalky stratum of decomposed bones above noted, and have been, unfortunately, lost. I found no description of the position of the skull mentioned by Ranke as afterwards found in the cave, and taken to England by Buckland.

Potsherds, according to Esper, were found at depths of three feet, and without more conclusive evidence, it must remain doubtful whether in this case the human bones were not intrusive and to be referred to a later time than that of the fossil animals. 54

In the bottom of one of the chasms, which had evidently been disturbed by previous digging to a considerable depth, my scratching brought to light two teeth, a lower jaw and leg bone of *Ursus spelaeus*. The wet stalagmitic walls of the rift were scantily bedded with bone fragments, and I saw many pieces set in loose fragments of breccia which recent fossil hunters had gouged out of the walls and found not worth taking away. No doubt crusts of stalagmite projecting here and there from the walls over the cave earth had been broken through, but I saw no signs of previously-existing floors of large extent in the chasm.

Here, where some loose bones steeped in carbonate of lime were hard as stone, while others projected from the drip looked comparatively fresh,[3] the value of breccia, of fossilization, and of stalagmitic crusts covering underplaced layers as tests of age seemed small. Still more was I inclined to reject such criteria when, a few days later, I was shown stalactites 60 centimeters long produced in fifteen years on the reservoir roof at Bayreuth, and when Professor Adami, of Bayreuth, told me that he had seen, in 1884, stalactites in a tunnel between Zelfenkasten and Conters (in Switzerland) 6 inches long and forty years old. It was soon apparent that a great deal of digging had been done in the cave. No doubt the searchers for "Unicorns horns" had been there before Esper. Doubtless "Neuhaus Hans" of recent local fame had found profit in the contents of down-reaching fissures. But, in spite of the frequent overturning of mould and breccia, it might not be impossible still to demonstrate the meaning of the layers at Gailenreuth. The bottoms of the chasms have probably, owing to the cramped space, never been reached, and several places may well exist in the upper chamber floors that have not been disturbed at all. However that may be, Gailenreuth, the starting point of modern cave exploration, shows well the bearings and the difficulties of real work done in caverns, and suggests many of the puzzles which still perplex the investigator.

H. C. Mercer.

[3] Like the Cave Bear and Lion skulls in the Schloss Museum at Bayreuth.

MICROSCOPY.[1]

Notes on Gold Impregnation Technique.—The following method of using formic acid and gold chloride is a modification, or adaptation of a method used by Miss Julia B. Platt and kindly suggested by her to me. She refers it to Professor Mark of Harvard University. I have used it in tracing the nervous system of *Nephelis lateralis* and have found it reliable. In leech tissues, it differentiates all nerve tissue, though the histology of other tissues is poor. After more than a year's use of this method without a complete failure among my preparations, I feel that Lee's characterization of the other methods of gold staining does not apply to this method.

It has been used successfully on larval vertebrate material as well as on leech tissue, by varying the strength of the formic acid, or the time of its application. The other factors are to a great extent indifferent as to strength used or time employed. If maceration occurs, lessen the action of the formic by weakening or by shortening the time. If the impregnation is slight, increase the action. The thickness of the piece stained should not exceed 5 mm., and the tissue must be living.

The following is the process employed with *Nephelis:*

The leech is put into twenty or thirty times its bulk of 10% formic acid and left from 3 to 5 minutes. It dies well extended. Transfer without washing to 1% Gold chloride (of commerce) for 25 minutes; then without washing into 1% formic acid for 24 hours, or until reduction is complete. This is indicated by a rich purple color over the whole specimen. Wash slightly in tap water; run up through the alcohols to chloroform; to chloroform saturated with hard paraffine. My sections are usually cut 16μ thick. When the impregnation appears to be very light—almost a failure, stain the sections on the slide with erythrosin or some other deep red anilin stain for contrast. These sections will often show the most exquisite details.

Transparent larvæ 5 to 10 mm. long require a milder treatment, such as the following: 5% formic acid 2 or 3 minutes, 1% or ½% gold chloride 10 minutes, weak formic 1 to 4 hours. If the specimens are watched from time to time under the dissecting lens, it will be seen that the central nervous system stains first and then the peripheral. The reduction of the gold chloride may be stopped, of course, at any point by transferring to alcohol.

[1]Edited by C. O. Whitman, University of Chicago.

All the operations described above were conducted in diffuse daylight and the gold chloride solution was exposed to sunlight for some time before using. This may not be an essential factor to the process, but Dr. L. Lindsay Johnson, in the third edition of Lee's *Vade Mecum*, suggests that failure to ripen the solution by sunning may be the cause of many of the failures in gold staining.

C. L. Bristol.

University of Chicago, April 14, 1894.

Gold Chloride–Formic Acid Staining of Sections after Fixation in Sublimate Alcohol.—S. Apathy in the the Zeitschrift für Wissenschaftliche Mikroskopie. Bd. X, 1893, p. 348.

The following method is extracted from an article on the muscle fibres of Ascaris.

Take equal parts of a saturated solution of corrosive sublimate in a ½ per cent solution of common salt and absolute alcohol; or dissolve 3 per cent of corrosive sublimate and ½ per cent common salt in 50 per cent alcohol. Use the liquid boiling hot for Ascaris, cold for leeches, and leave the animals in it for 24 hours, or at least 12 hours. Wash out in 50 percent alcohol until the mahogany-brown color of an iodine-alcohol solution remains unchanged for a few days. Free the tissues from iodine in 90 per cent alcohol. Imbed in paraffin, using chloroform for the transferring medium, and fix the sections on the slide. Free them completely from paraffine and chloroform, and finally wash slightly with distilled water.

Put the slide in a 1 per cent gold chloride solution and keep in the dark for 24 hours. Drain the slide and lightly apply a smooth-faced blotting paper to take up the surplus liquid. A $\frac{1}{10}$ per cent solution of gold chloride will answer, and is, of course, cheaper. Without further washing put the slide in a large bulk of 1 per cent formic acid and leave it for 24 hours. The longer diffuse daylight acts on the sections, the better the results. Wash in distilled water and mount in balsam. The sections may be cut very thin or thick—from 1μ to 15μ, but the author found the best results from sections 2 or $2\frac{1}{2}\mu$ in thickness.

"By this simple procedure, founded on a well known method, are produced the most beautiful pictures of the finer details of various tissues, but especially muscle and nerve fibres. The various elements of the tissue are stained in different tints from rose to cherry red or red-brown and are sharply defined."

A Rapid Method of Hardening and Sectioning.[2]—Every practical pathologist must be convinced of the great importance, in many cases, of at once supplementing and completing the naked eye examination of structures by a thorough microscopic examination. Microscopic examination in the fresh state, by teasing up parts of tissues, or by means of scrapings from the cut surface, is in most cases imperative if the finer details of the cellular elements are to be fully appreciated, but sections are no less necessary in many cases if the relations of the various constituents, and the structure with the tissue as a whole, are to be determined. In order to do this the method of freezing the fresh tissue, and cutting sections with the microtome is frequently adopted, but it must be the general experience that such sections are often very unsatisfactory. They are so loose and lacking in cohesion, and the process of freezing alters the tissue so much, that they are difficult to manipulate and often difficult to interpret. I have occasionally met with errors in diagnosis made by incompetent observers from the use of such sections. In order to obtain satisfactory results, the processes of hardening, embedding, section-cutting, staining, and mounting are all necessary, and these commonly extend over several days. If the process can be so shortened that the whole investigation can be completed at one sitting, then a considerable practical advantage will be obtained. How often does it happen in the course of a pathological investigation of parts either obtained post-mortem or from operation that we wish to be satisfied on the spot as to the real significance of some particular appearance. If the structure is put aside to harden, there is considerable likelihood of some of the points being forgotten, and, at any rate, it is not taken up with the freshness of the first examination. I believe also that for purposes of surgical diagnosis an examination made within an hour's time would often be found of great value.

The method I have now to describe has no claim except as a practical working procedure. I have mentioned it to several friends, and have met with a general expression of its usefulness. I have used it constantly for more than a year, and am perfectly satisfied that it fulfils its purpose. The principles of the method are: (1) rapid hardening in alcohol; (2) cutting with the microtome without removing the alcohol and without freezing the tissue; (3) rapid staining.

1. The hardening is effected by absolute alcohol, kept at a temperature about that of the animal body. In examining the fresh tissue

[2]Journ. Pathology and Bacteriology, II, No. 4, May, 1894.

with the naked eye the pathologist makes up his mind as to what exact parts he desires to submit to microscopic examination. With a sharp knife he takes a thin slice of such a part, not more than two to four millimetres in thickness and of comparatively small superficial area. The piece of tissue is placed in a test-tube containing some cotton-wool at the bottom, and half-filled with absolute alcohol. The slice is so placed in the tube that it shall lie flat and not be distorted or curved. The vessel is now to be placed at a slightly elevated temperature, for which purpose a water bath is most suitable. I use a hand basin, the hot tap of which is left running so as to keep the water at a temperature which may be judged of by the hand. The slight current in the water is a distinct advantage. If the piece be at all bulky it may be well to renew the alcohol after a short interval. In the course of half an hour or three quarters the slice of tissue will generally be found sufficiently hardened to be proceeded with further.

2. In the next stage advantage is taken of the fact that anise-oil freezes at a comparatively high temperature (45° to 70° Fahr.), and that the presence of alcohol does not interfere with the process of freezing. My attention was called to this agent by a paper by Kühne. This author recommends anise-oil as an embedding material, but I have not found the method which he recommends very successful. I use the anise-oil, not to penetrate the tissue, like celloidin or paraffin, but rather to hold it and fix it on the plate of the microtome. Having taken the slice of tissue from the alcohol, I dry it with blotting-paper or an absorbent cloth. I then pour a few drops of anise-oil on the plate of the freezing microtome, and place the piece of tissue in the midst of the oil. It is better to have the oil making one convex drop with the specimens in the middle of it, as in cutting the sections the less oil you take with you the better. A few systoles of the ether-spray bellows suffice to freeze the oil into a white solid mass. The knife is now used with a considerable sweep, and the section may be cut dry if its superficial area be small. If this cannot be done without risk of tearing, then the upper surface of the blade may be moistened with alcohol. The microtome which I use for the purpose is a Schantze, and any microtome with a sliding knife will serve. It is possible, by this method, to obtain sections sufficiently thin for most purposes, although not equal, of course, to those which may be got after embedding in celloidin or in paraffine.

In regard to the size of the piece of tissue to be cut, it is certainly better to have it of small dimensions, but the method is perfectly applicable to such a piece as would involve, say, the whole thickness of the kidney including cortex and pyramids.

After the sections are made they are placed in alcohol, which dissolves the anise-oil.

The sections so obtained may be stained with any of the ordinary agents. I used Biondi's fluid a good deal; it is rapid and differentiates well. Perhaps the most generally useful stain is Mayer's carmalum. This has all the advantages (and they are many) of alum-carmine, and has some additional ones of its own. Thus it is much brighter in tint, and so forms a better contrast. This is of special service when Gram's or Weigert's method is used for the detection of microbes, as the blue tint of alum-carmine is often objectionable when the microbes are stained blue. I commonly use picric acid as a contrast stain with the carmalum. The solution used consists of alcohol seventy parts, saturated watery solution of picric acid 30 parts, and hydrochloric acid ½ part. I find the results obtained to be much better than those yielded by picrocarmine in my hands. The whole process of staining by carmalum and picric acid need not take many minutes. If necessary a gentle heat may be used to hasten the action. An excellent method of staining, in many respects, is that described by Nicolle. It is introduced as a method of staining microbes which do not stain by Gram's method. The staining agent is Kühne's or Sœffler's blue. I have used, chiefly, Kühne's blue, which acts very rapidly, a few seconds being usually enough. It is so very vigorous, that dilution is sometimes necessary. The section is then washed in water and treated with a 10 per cent. solution of tannic acid. This has the effect of fixing the blue color in nuclei and microbes, so that subsequent treatment with alcohol and oil of cloves will not remove the color. The section is taken from the tannin solution, washed in water, dehydrated with alcohol, cleared with oil of cloves, washed in xylol, and mounted in Canada balsam in the usual way. If a contrast stain he desired, then eosin or acid fuchsine may be added to the tannin solution.

To summarise the method it may be put as follows:

1. Select an illustrative part of the fresh tissue, and remove a slice with a sharp knife.
2. Place in absolute alcohol and heat the vessel in a water bath to about 40° C. for half an hour to an hour.
3. Dry the tissue and place on the freezing plate of the microtome in a large drop of anise-oil.
4. Freeze and cut sections. The upper surface of the knife may be moistened with alcohol while cutting.
5. Place in alcohol to remove anise-oil.
6. Float out in water and place on slide for staining.
7. Stain by any approved rapid method, and mount.—JOSEPH COATS, M. D.

SCIENTIFIC NEWS.

Walker Prizes in Natural History.—Two prizes are annually offered by the Boston Society of Natural History for the best memoirs written in the English language on the subjects given below. For the best memoir presented a prize of sixty dollars may be awarded; if, however, the memoir be one of marked merit, the amount may be increased to one hundred dollars, at the discretion of the committee. For the next memoir, a prize not exceeding fifty dollars may be awarded. Prizes will not be awarded unless the memoirs presented are of adequate merit. The competition for these prizes are not restricted, but open to all. Each memoir must be accompanied by a sealed envelope enclosing the author's name and superscribed with a motto corresponding to one borne by the manuscript, and must be in the hands of the Secretary on or before April 1st of the year for which the prize is offered.

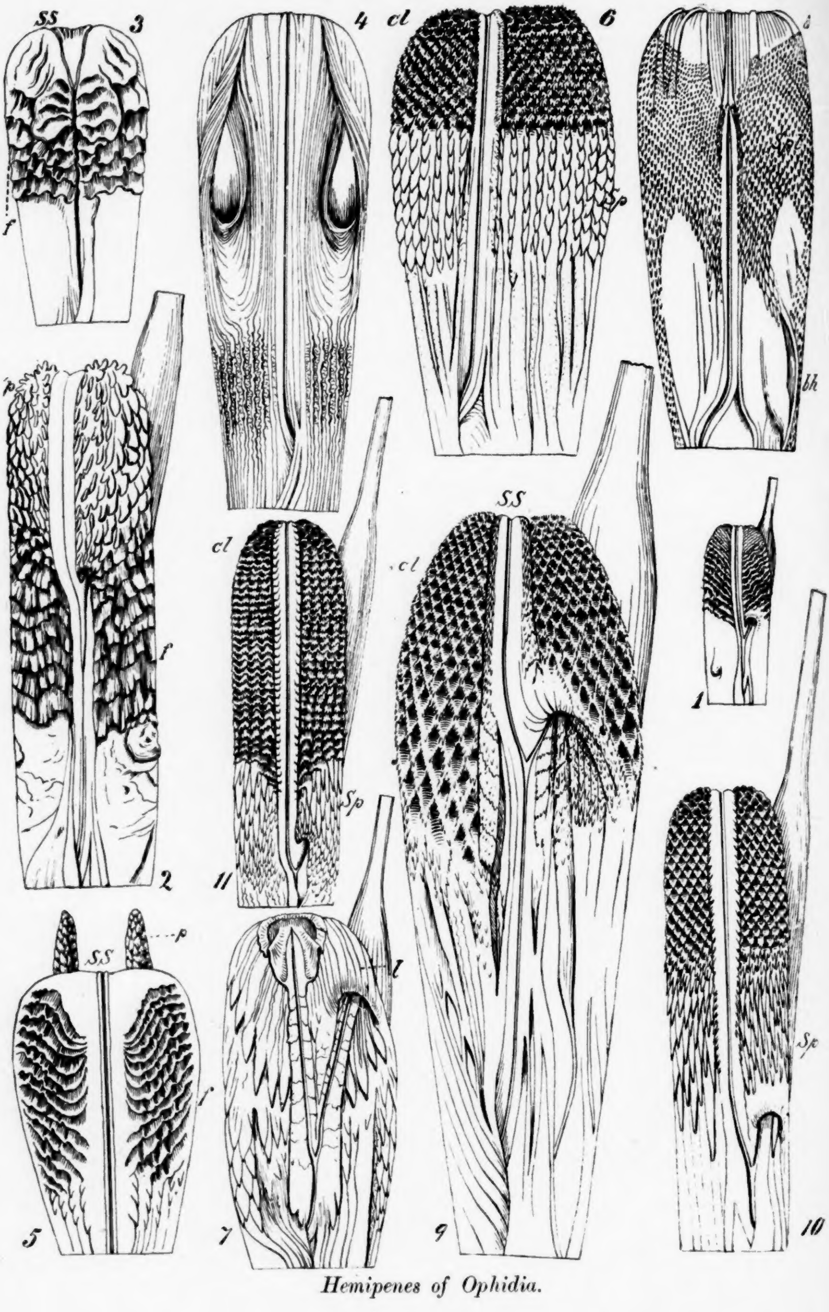
Subjects for 1895:—(1) A study of the "Fall line" in New Jersey; (2) A study of the Devonian formation of the Ohio basin; (3) Relations of the order Plantaginaceae; (4) Experimental investigations in morphology or embryology.

Subjects for 1896:—(1) A study of the area of schistose or foliated rocks in the eastern United States; (2) A study of the development of river valleys in some considerable area of folded or faulted Appalachian structure in Pennsylvania, Virginia or Tennessee; (3) An experimental study of the effects of close-fertilization in the case of some plant of short cycle; (4) Contributions to our knowledge of the general morphology or the general physiology of any animal, except man.

Note.—In all cases the memoirs are to be based on a considerable body of original work, as well as on a general review of the literature of the subject.

Samuel Henshaw,
Secretary.

PLATE XXVII.



Hemipenes of Ophidia.

THE

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THE CLASSIFICATION OF SNAKES.

BY E. D. COPE.

Owing to the absence of limbs and other points in which diversity is usually apparent, the classification of the snakes has always presented difficulties to the zoologist. An order which dates from Cretaceous time and has spread over the entire world, must have differentiated in structure, if its history has been like that of other orders of Vertebrata. Yet the researches of anatomists have only resulted in finding characters which define five suborders, and about a dozen families. Of the natural groups thus defined, one family, the Colubridæ, embraces three-fourths of the species, and is of cosmopolitan distribution. So long as this was the principal result attained, it remained clear that the stronghold of the order had not yet been taken.

The primary divisions above referred to, are defined by peculiarities of the skeleton, and these were mostly originally described by Johannes Müller. In the preparation of their Herpetologie Générale, Duméril and Bibron made a full study of the dentition. The results they obtained were important, but they were very far from expressing an exact and clear cut classification. The greatest defect of their definitions based on the teeth is that they too often fail to define. One type passes by easy gradations into another, so that in many cases it is im-

possible to determine what type a given dentition represents. In most cases it is clear that, among Colubrid snakes at least, no higher groups than genera can be predicated on dentition, and frequently not even these. Under such circumstances further structural characters had to be sought for if we are to have any clear idea of the affinities and phylogeny of this curious branch of the Reptilia. In any case no systematic arrangement can be regarded as final until the entire anatomy is known.

In 1864[1] I pointed out that certain snakes, notably the water snakes, have the vertebral hypapophyses continued to the tail, as in the truly venomous forms. Boulenger has since found this character in a good many forms which I had not examined, and which have no affinity to the water snakes. This character, while important, presents the same evanescent stages in certain types that the dental characters before noticed exhibit. It had long appeared to me that the only prehensile organs possessed by serpents, the hemipenes, might probably present structural variations expressive of affinity or diversity. In 1893[2] I examined these structures in many of the leading types, and was gratified by the discovery of a great many structural characters. In fact these organs exhibit a variety of ornamentation and armature beyond any part of the anatomy in the Ophidia, and I am satisfied that they furnish more important indication of near affinity than any other part of these reptiles yet examined. No one hereafter can be sure of the place of a serpent in the system until the hemipenis has been examined.

Still another part of the structure remained to be studied. The assymmetry of the lungs of snakes had often been noted by anatomists, but very little was known as to the range of variation. Accordingly the present year,[3] I undertook a study of the pulmonary organs. I was able to confirm observations previously made by Schlegel and Stannius, and to correct some others, and to add a great number of facts as to species not

[1] Proceedings Academy of Natural Sciences, Philada.

[2] American Naturlist, 1893, p. 477.

[3] Proceeds. Amer. Philos. Soc., 1894, p. 217.

previously examined. I cannot give here all the details observed, for which I refer to the papers quoted, but I give a general view of the results. One of these is that I am able to confirm the conclusion of Boulenger; i. e, that the Colubriform venomous snakes, the Proteroglypha, (cobras, Elapes, etc.), do not differ in any fundamental respect from the non-venomous Colubridæ, and that they can not be characterized as a suborder. The suborders then are:

Catodonta (Type Glauconia).
Epanodonta (Type Typhlops).
Tortricina (Ilysiidæ and Rhinophidæ).
Colubroidea (Peropoda, Asinea, and Proterogylpha).
Solenoglypha (Typical venomous forms).

The hemipenis is a projectile organ in the form of a hollow tube whose base is on one side of the middle line, and which opens into the anus. When retracted it lies beneath the tail, extending for a greater or less distance, and terminating in a cylindrical muscle. This has considerable length, and is finally inserted on a caudal vertebra. When the organ is projected this muscle is drawn forwards, so as to evaginate the tubular organ. Thus the inside of the tube becomes the outside, and the entire organ projects freely from its base anteriorly. It finds its way into the corresponding oviduct of the female (Plate XXVIII, v), and when once in place it cannot be tracted in most species, without invagination. This is performed by the contraction of the now internal retractor muscle. This is inserted on the internal face of the apex, and draws it inwards, so that it soon assumes the original ensheathed position beneath the tail. It cannot be withdrawn from the oviduct without invagination, because it is generally set with strong bony spines which diverge backwards. They have a perfect grip on the walls of the oviduct, and would in some instances lacerate that organ if the two bodies should be forcibly drawn apart. In other cases the hemipenis would be torn off at the base. Snakes sometimes partially project this organ, apparently in some instances for defence, as the spines are very pungent, and are sometimes curved like cats claws. Such at least would seem to have been the

case with two *Heterodon platyrhinus*, (spotted adders), which were brought to me with the organs projected so as to present the spines. They were caught by a cat, and were represented to me as fighting their captor in this and other ways. Snakes are, however, very careful not to present these organs fully evaginated so as to expose the delicate structures near the apex. I have never seen this to be the case in an alcoholic specimen, (with one possible exception), and I should judge that this was the general experience, from the figures given by authors. It is said that male snakes may be compelled to project the hemipenes by holding them before a fire, but I have not seen this.

The hemipenis of the Ophidia is traversed by a groove which divides the superficial investment to the internal integument (or external integument when the organ is retracted), which commences at the base internally, and soon turns to the external side of the organ and continues to its extremity. This is the sulcus spermaticus (s s in Plate xxvii). This sulcus is always bifurcated in venomous snakes, and I find it to be equally bifurcated in many harmless snakes (Figs. 2, 3, 7). The investing tissues may or may not correspond with this bifurcation. Thus the hemipenis may be more or less bifurcate (Figs. 1, 2, 7, 9, 10, 11). Schlegel states that it is bifurcate in venomous snakes, but it is not so in the sea-snake *Hydrophis hardwickii*, nor in *Bungarus semifasciatus*, *Hoplocephalus coronatus*, etc., while it is bifurcate in many non-venomous forms. Next to the bifurcation of the sulcus in importance, is the nature of the surface of the external investment (internal when retracted). In the most perfect types both venomous and non-venomous, this surface is reticulate like tripe, the enclosed areas forming calyces, which may have a suctorial function (Figs. 6, 9, 10, 11). Their borders are often papillose, and are sometimes so deeply divided into papillæ as to lose their original character. These papillæ may be the seat of osseous deposit, becoming bristles or spines, (sp), which become larger toward the middle of the length, and lose their mutual membranous connections. These isolated spines may extend to the apex, but they rarely extend to the base. The surface may, however, be laminate and not reticulate, and the laminæ may

be longitudinal (Figs. 4, 7) or transverse (Figs. 1, 2, 3, 5). In either of these cases they may not be spiniferous. The apex or apices of the organ may be furnished with a rigid papilla (Fig. 5) or awn.

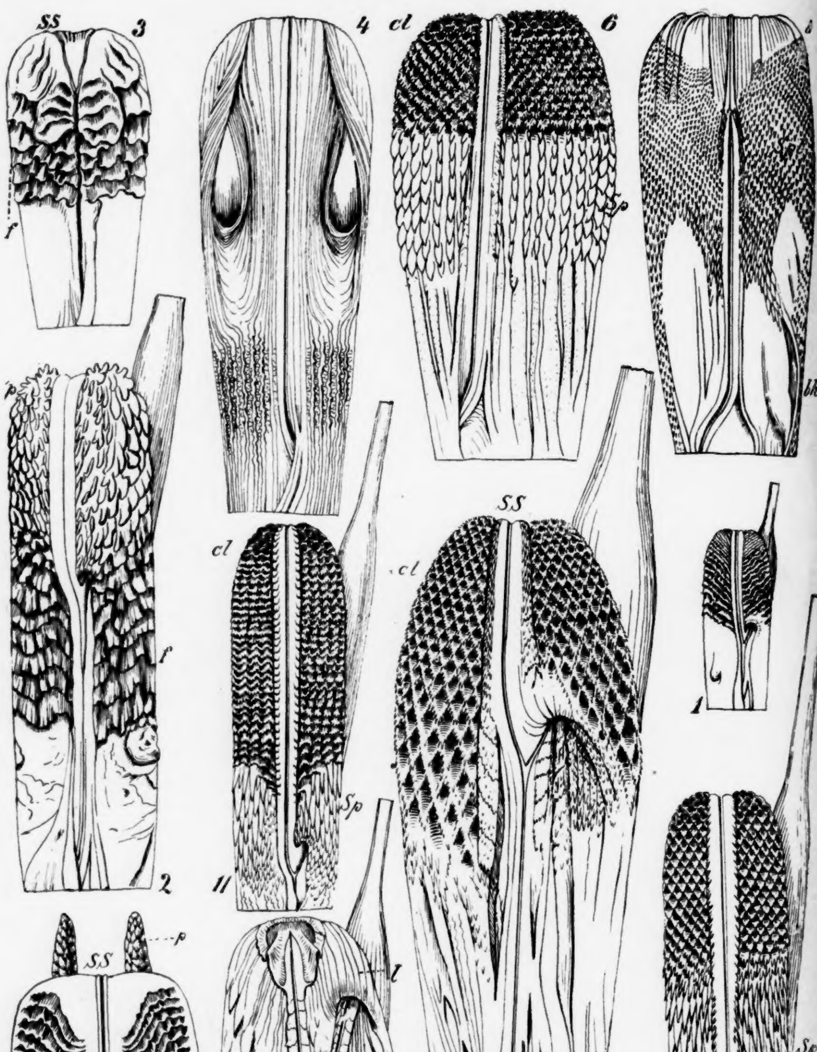
In the Tortricina and Peropoda (the constrictors), the hemipenis is not spinous, and the sulcus is bifurcate (Figs. 1, 2, 3), and in the Boidae the hemipenis is bifurcate also, although in some genera (Xiphosoma, Ungualia), the branches are very short. The external integument is never reticulate, but is always laminate with elongate papillæ at the extremities, in Epicrates (Fig. 2), Xiphosoma, and Ungualia. The laminæ are pinnate from the sulcus as an axis, in Morelia, Enygrus, Lichanura and Eryx, and are transverse (flounced), in Charina (Fig. 3). In Ilysia they are pinnate (Fig. 1), with a few longitudinal plicæ below.

Similar gradations in the characters of the hemipenis are to be seen in the types of venomous snakes. Thus in the Proteroglypha this organ is spinous to the tip, on a calyculate basis, in Hydrophis, Elaps, (*surinamensis*); Dendraspis. It is reticulate at the extremities and spinous below, in Callophis (*bivirgatus*); Naja (Fig. 9); Acanthophis; Bungarus and Sepedon; the apex smooth in the two genera last named. In *Elaps nigrocinctus* the organ is smooth below, with spines at the apex.

In Solenoglypha the genus Atractaspis is spinous to the apex, apparently on a longitudinally laminate basis. In the Viperidæ and Crotalidæ the spines are on a flounced basis. The apices are calyculate in Bitis, Clotho (Fig. 10), and Vipera, and spinous in Cerastes. They are calyculate in Crotalidæ in Bothrops, Ancistrodon, Crotalophorus, Crotalus and Uropsophus (Fig. 11). In Crotalus (*durissus* of the Neotropical fauna), the papillae are not ossified; in all the other genera they are spinous.

The condition of knowledge as to the lungs of snakes was stated by Stannius, in 1856, as follows: "The detailed accounts as to the single or double character of the lungs leaves much to be desired. Among Ophidia Angiostomata there possess a single sack, Rhinophis and all Typhlopidæ

PLATE XXVII.



Hemipenes of Ophidia.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